FRACTURES OF BOTH BONES FOREARM – A COMPARATIVE STUDY ON FIXATION TECHNIQUES AND FUNCTIONAL OUTCOME BETWEEN INTRAMEDULLARY NAILING AND PLATE OSTEOSYNTHESIS

DISSERTATION SUBMITTED FOR

MASTER OF SURGERY DEGREE EXAMINATION

BRANCH II (ORTHOPAEDIC SURGERY)

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CHENNAI, TAMIL NADU

CERTIFICATE

This is to certify that the work entitled **FRACTURES OF BOTH BONES FOREARM – A COMPARATIVE STUDY ON FIXATION TECHNIQUES AND FUNCTIONAL OUTCOME BETWEEN INTRAMEDULLARY NAILING AND PLATE OSTEOSYNTHESIS** which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr. S. NITHYANANTH**, Post Graduate Student at Department of Orthopaedics, Madurai Medical College, Madurai.

DEAN

Madurai Medical College

Madurai

CERTIFICATE

This is to certify that the work entitled **FRACTURES OF BOTH BONES FOREARM – A COMPARATIVE STUDY ON FIXATION TECHNIQUES AND FUNCTIONAL OUTCOME BETWEEN INTRAMEDULLARY NAILING AND PLATE OSTEOSYNTHESIS** which is being submitted for M.S. Orthopaedics, is a bonafide work of **Dr. S. Nithyananth**, Post Graduate Student at Department of Orthopaedics, Madurai Medical College,Madurai.

He has completed the necessary period of stay in the Department and has fulfilled the conditions required for the submission of this thesis according to the University regulations. The study was undertaken by the candidate himself and the observations recorded have been periodically checked by us.

Recommended and forwarded

Prof. P.V. PUGALENTHI

Prof. & HOD, Dept. Of Orthopaedics,
Madurai Medical College
Madurai

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Abstract

Background and Objectives

In the current era of industrialization, and with mechanized farming in India, fractures of forearm bones have become more common. The forearm serves an important role in the functioning of the upper extremity. Hence aggressive management becomes essential .The purpose of this study was to evaluate subjective and functional outcome after osteosynthesis of the forearm fractures with plates and screws (ORIF) or Elastic nailing (CRIF).

Methods

We evaluated 20 patients who underwent internal fixation of forearm fractures with CRIF(10 patients) or ORIF (10 Patients), concerning the Range of motion of forearm , elbow and a validated outcome measure.(Modified Grace Eversmann scoring system) and standardized radiographs of the forearm were evaluated. We used CHI square test to evaluate the results.

Results

There was a statistically significant difference in the final outcome in patients undergoing ORIF with Plate and CRIF with Titanium elastic nail, with better functional outcome in the latter. However the risk of non union and reintervention was not different between the groups.

Conclusion

Forearm bones fractures are associated with high rates of consolidation and satisfactory mobility of the forearm since we obtain an anatomic reduction of the fracture, as is most easily achieved by plate fixation. However Elastic nailing is a less invasive technique that allows restoring function more quickly with less pain and no increased risk of complications.

PART A

PART B

PART A

INTRODUCTION

Increasing incidence of road traffic accidents, natural disasters and industrial accidents together with assault leads to multiple fractures and higher incidence of morbidity. They form the major epidemic of modern era. 0f these, the fractures involving both the bones of forearm form an important part. Even though these fractures can be treated successfully by surgical methods, the anatomical reduction of fracture fragments becomes absolutely essential for effective postoperative function. Delayed hospitalization, use of indigenous bandages and associated vascular and nerve injures contribute to increased incidence of morbidity.

Traditionally majority of adult forearm fractures are treated by traditional bone setters leading to various complications. Awareness about the role of various types of surgical fixation and their role in successful management of forearm fractures is absolutely essential for preventing this practice.

Fracture of the forearm bones may result in severe loss of function unless adequately treated. Hence good anatomical reduction and internal fixation of these fractures is necessary to restore function.[1]

For effective pronation and supination to occur, the maintenance of interosseous space becomes mandatory while fixing the fractures involving radius and ulna. Presence of comminution, the anatomy of fracture pattern and presence of rotatory malalignment significantly contribute to the postoperative morbidity in these fractures.

Better understanding of the injury patterns, availability of better implants, the concept of early surgical fixation and exact post operative protocol all have convincingly improved the functional outcome of the patient to a larger extent.

The successful management of these fractures demands familiarity with the character of fracture, technical aspects of fracture fixation, the varieties of implants available for fixation and the art of postoperative management.

HISTORICAL REVIEW

Fractures are known to occur since evolution of mankind. However Prehistoric man must have had his troubles with broken bones. According to Sudhoff, the bones of Neolithic man showed traces of attempts at corrections of deformities. Apparently enough specimens of fractured bones from that age have been found to justify statistical statements.[2]

Recorded descriptions of the methods of fracture treatment dates back to Egyptian times, which has been clearly mentioned in **Edwin Smith Surgical Papyrus.**Egyptians used palm bark and linen bandages for management of fractures. Clay and lime mixed with egg white were used, but the material most commonly used has been, the wood.[3]

Till the end of 19th century, the fractures of both bones of forearm were managed conservatively with POP cast immobilization. In the early 1900s, Lane in London and Lambotte in Belgium reported use of plates for treating diaphyseal fractures. However, metal reaction led to frequent failures until modern metals were introduced in 1937 by Veriable and associates. Campbell and Boyd used autologous tibial grafts fixed to the radius and ulna with bone pegs or screws.

Even after better metals became available, many early plates were poorly designed which led to failures. Slotted plates were introduced by Eggers and associates by late 1960s. The idea of using plates through which active compression could be applied began with Danis of Belgium. In 1958, Muller, Allgower and Willenegges developed what is now known as AO compression plates. The technique of using these plates was published in 1965, and these became the standard mode of fixation since then.

With the advent of intramedullary nails for fractures of shaft of femur, various devices for intramedullary fixation of radius and ulna was introduced in 1957 by Smith and Sage. They used Krischner wires, rush nails, small 'V' nails and Steinmann pins for fixation. The results were discouraging. In1959, Sage introduced triangular forearm intramedullary nails. In 1986, Street introduced the concept of reamed forearm nails.

A study showed that certain long oblique fractures could be fixed with two screws. Also satisfactory intramedullary fixation could be achieved by using prebent diamond shaped nails by SMITH.[4]

Recently interlocking nails for both radius and ulna were introduced. Titanium elastic nails which were developed for fractures of shaft of long bones in pediatric and adolescent age group are being used now in adult diaphyseal forearm fractures.

ANATOMY[5,6]

Fractures of forearm bones may result in severe loss of function unless adequately treated. The relationship of the radiohumeral, proximal radioulnar, ulnohumeral, radiocarpal and distal radioulnar joints and the interosseous space must be anatomical or else some functional impairment will result, due to the involvement of these various joints.

Embryology[5].

Development of the limb buds. Limb development may be conceptualized as the result of a series of ectodermal-mesenchymal interactions.

• The upperlimb bud appears on 26th day (end of 4th week) as small bulges on the lateral body wall at about the level of C5 – C8.

• By 4th week they have grown to form noticeable, coronally oriented ridges.

• Limb morphogenesis takes place from 4th to 8th week.

• By 33 days the hand plate is visible.

• Digital rays appear on hand during 6th week. By 6th week end segments of upper limb can be distinguished.

• By the 50th day or so (8th week) the elbows and shoulder are established, and the fingers are free.

• Each limb consists of a mesenchymal core of mesoderm, covered by ectodermal cap.

• Skeletal elements of limbs develop from a column like mesodermal condensation that appears along the long axis of the limb during 5th wk and full differentiation by 12th wk.

• Ossification begins in these cartilaginous precursors in 8th to 12th wk.

• Rotation of limbs occurs during 6th to 8th week

SKELETAL ANATOMY [6]

Forearm consists of skeletal structures; interosseous membrane; stable proximal and distal radio-ulnar joints; and soft-tissue structures, including the muscles, nerves, and vessels that are in the forearm and that traverse it.

RADIUS[6]

The radius is the lateral bone of the forearm. Its proximal end articulates with the trochlea of the humerus at the elbow joint and with the ulna at the proximal radioulnar joint. Its distal end articulates with the scaphoid and lunate bones at the distal radioulnar joint.

At the proximal end of the radius is the small circular, head. The upper surface of the head is concave and articulates with the convex capitellum of the humerus. The circumference of the head articulates with the radial notch of the ulna. Below the head is the neck, below which there is the bicipital tuberosity for the insertion of biceps muscle. The shaft of the radius is wider below. It has a sharp interosseous border medially for the attachment of interosseous membrane. The pronator tuberosity for the insertion of the pronator teres muscle, lies half way down on its lateral side.

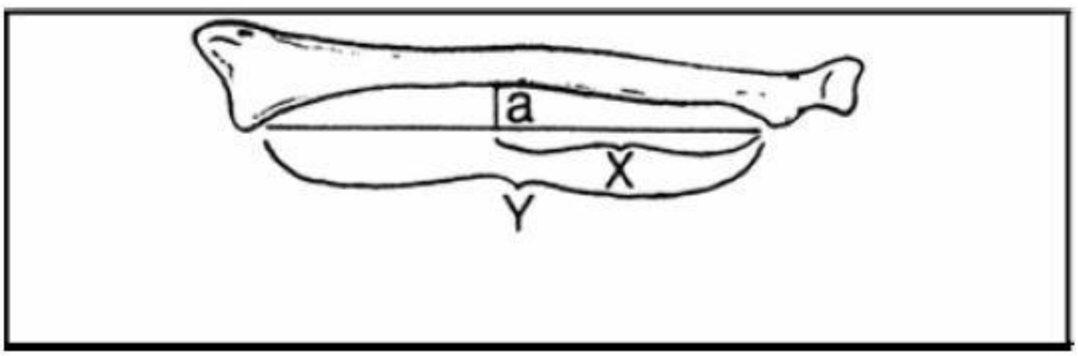
At the distal end of the radius is the styloid process; this projects distally from its lateral margin. On the medial surface is the ulnar notch, which articulates with the distal ulna. The distal articular surface articulates with the scaphoid and lunate bones. On the posterior aspect of the distal end is a small tubercle, the dorsal tubercle of Lister, which is grooved on its medial side by the tendon of extensor pollicis longus.

Radius ossification

The radius ossifies from three centres (one primary centre and two secondary centres). One appears centrally in the shaft in the eighth week of foetal life, and the others appear in each end. Ossification begins in the distal epiphysis towards the end of the first postnatal year, and in the proximal epiphysis during the fourth year in 28 females, and fifth in males. The proximal epiphysis fuses in the fourteenth year in females, seventeenth in males, and the distal in the seventeenth and nineteenth years respectively. A fourth centre sometimes appears in the tuberosity at about the fourteenth or fifteenth year.

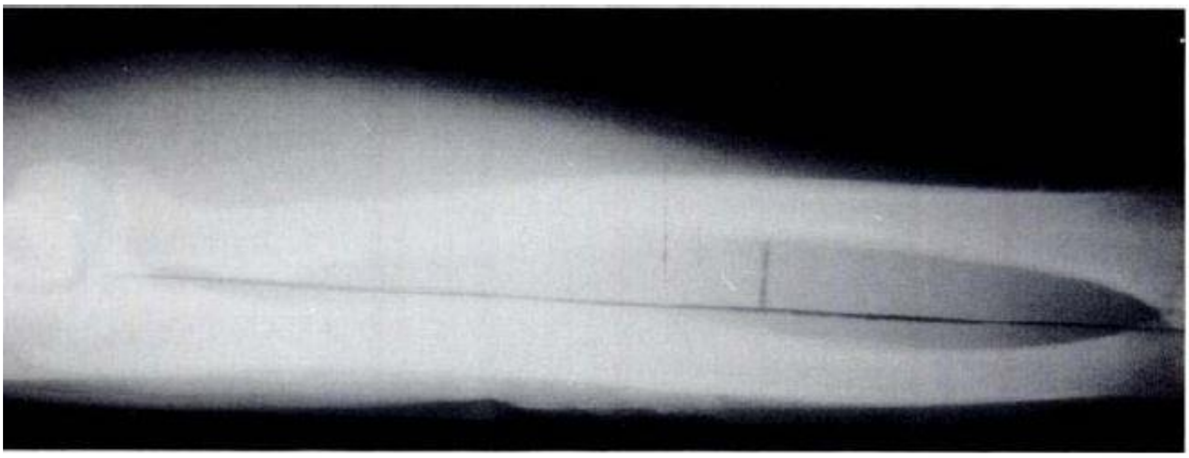
Technique of Schemitsch and Richards[7]

To measure the radial bow, a line is drawn from the bicipital tuberosity to the most ulnar aspect of the radius at the wrist. A perpendicular line is then drawn from the point of the maximum radial bow to this line. The height of the perpendicular line (the maximum radial bow) is measured in millimetres. The distance from the bicipital tuberosity to the previously measured perpendicular line at the point of the maximum radial bow is then measured and is recorded as a percentage of the length of the entire bow (the distance from the mid-point of the bicipital tuberosity to the most ulnar aspect of the subchondral bone of the distal part of the radius). This measurement is termed the location of the maximum radial bow. *The value is expressed as a percentage.*



MAXIMUM RADIAL BOW -- a (mm)

LOCATION OF MAXIMUM RADIAL BOW -- x/y x 100



ULNA[6]

The ulna is not a straight bone. It has a dorso medial bowing. The proximal end articulates with the humerus at the elbow joint and with the head of the radius at the proximal radioulnar joint. Its distal end articulates with the radius at the distal radioulnar joint, but it is excluded from the wrist joint by the articular disc.

The proximal end of the ulna forms the olecranon process. It has a notch on its anterior surface, the trochlear notch, which articulates with the trochlea of the humerus. Below the trochlear notch is the triangular coronoid process, which has on its lateral surface the radial notch for articulation with the head of radius.

The shaft of ulna tapers from above down. It has a sharp interosseous border laterally for the attachment of the interosseous membrane. The posterior border is rounded and subcutaneous. Below the radial notch is a depression, the supinator fossa, which gives clearance for the movement of the bicipital tuberosity of the radius. The posterior border of the fossa is sharp and it is known as the supinator crest: it gives origin to the supinator muscle.

At the distal end of ulna is the small rounded head, which has projecting from its medial aspect, the styloid process.

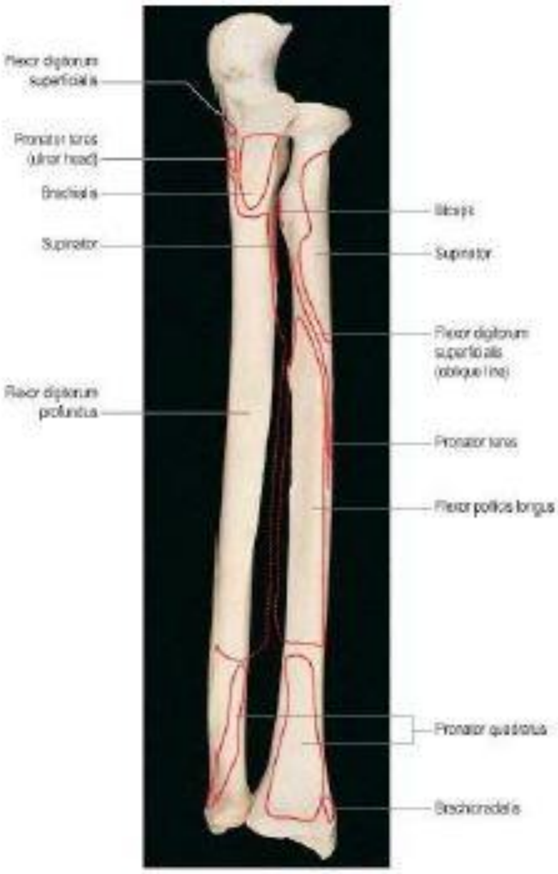
Ulna ossification

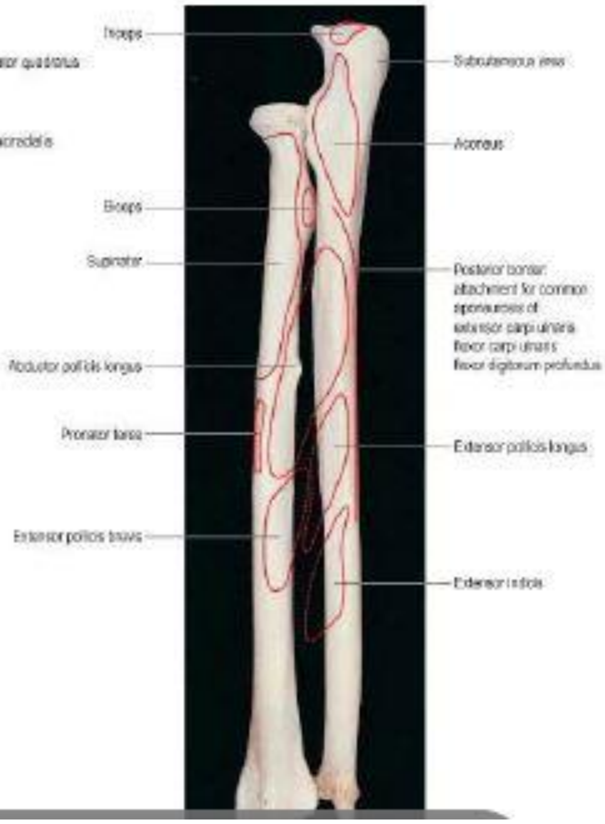
The ulna ossifies from four main centres (one primary center for the shaft and secondary centers, one for distal end and two for olecranon). Ossification begins in the midshaft about the 8th fetal week, and extends rapidly. In the 5th (females) and 6th (males) years, a centre appears in the distal end, and extends into the styloid process. The distal olecranon is ossified as an extension from the shaft, the remainder from two centres, one for the proximal trochlear surface, and the other for a thin scale-like proximal epiphysis on its summit. The latter appears in the 9th year in females, 11th in males. The whole proximal epiphysis has joined the shaft by the 14th year in females, 16th in males. The distal epiphysis unites with the shaft in the 17th year in females, 18th in males.

INTEROSSEOUS MEMBRANE[6]

This connects the borders of two bones. The interosseous membrane is a broad, thin, collagenous sheet. Its fibres slant distomedially between the radial and ulnar interosseous borders, and its distal part is attached to the posterior division of the radial border. The membrane is deficient proximally, starting 2 or 3 cm distal to the radial tuberosity, and broader at midlevel. An oval aperture near its distal margin conducts the anterior interosseous vessels to the back of the forearm, and the posterior interosseous vessels pass through a gap between its proximal border and the oblique cord. The membrane provides attachments for the deep forearm muscles. Its fibres appear to transmit forces which act proximally from the hand to the radius, thence to the ulna and humerus.

Forearm bones – Radius and Ulna





<u>**The radioulnar articulations:**</u>[6]

The radius and ulna are joined to each other at the superior and inferior radioulnar joints. The two bones are also connected by the interosseous membrane; which is sometimes said to constitute a middle radioulnar joint.

<u>**a. Superior radioulnar joint**</u>:

The proximal radioulnar joint is a uniaxial pivot joint. The articulating surfaces are between the circumference of the radial head and the fibro-osseous ring made by the ulnar radial notch and annular ligament

The essential structure is the annular ligament which holds the head of radius in place. The annular ligament is attached to the anterior and posterior margins of radial notch of ulna and has no attachment to radius. Superiorly it blends with the capsule at the lower margin of the cylindrical articular surface.

Movement-pronation and supination of forearm

<u>**b. Inferior radioulnar joint**</u>:

The distal radio-ulnar joint is a uniaxial pivot joint. The articulating surfaces are between the convex distal head of the ulna and the concave ulnar notch of the radius. These surfaces are connected by an articular disc.

It is closed distally by a triangular fibrocartilage which is attached to its base to the ulnar notch of radius and by its apex to a fossa at the base of ulnar styloid.

Movement-pronation and supination of forearm

The various muscles attached to radius are [6]

Proximal third

(1) Biceps brachiaii (insertion)

(2) Supinator (insertion)

(3) Pronator teres (insertion)

(4) Flexor digitorum superficialis (origin)

Middle third

(1) Flexor pollicis longus (origin)

(2) Abductor pollicis longus (origin)

Distal third

(1) Pronator quadratus (insertion)

(2) Branchioradialis (insertion)

(3) Extensor pollicis brevis (origin)

The various muscles attached to ulna are

Proximal third:

1) Brachialis (insertion)
2) Pronator teres (origin)
3) Flexor pollicis longus (origin)
4) Triceps (insertion)
5) Anconeus (insertion)
6) Supinator (origin)
7) Abductor pollicis longus (origin)

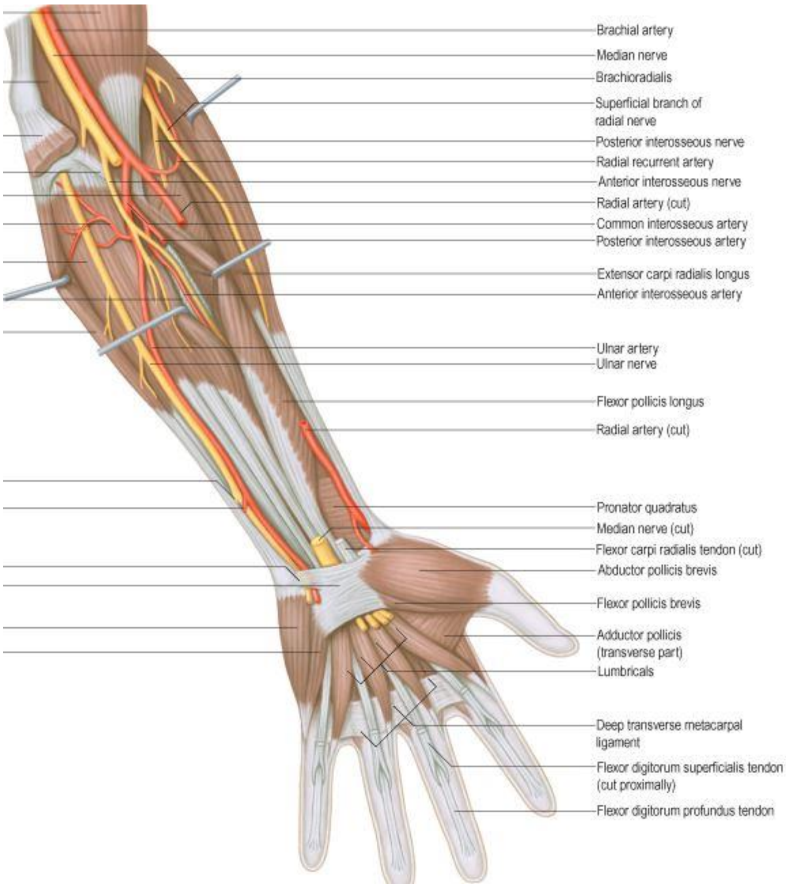
Middle third

1) Flexor digitorum profundus (origin)
2) Flexor carpi ulnaris (origin)
3) Extensor carpi ulnaris(origin)
4) Extensor pollicis longus (origin)

Distal third

1) Extensor indices (origin)
2) Pronator quadratus (origin)

Superficial and Deep muscles of forearm



VASCULAR SUPPLY OF FOREARM[6]

Radial artery

Originates from brachial artery at about 1 cm distal to the flexion crease of the elbow.

It descends along the lateral side of the forearm, The artery is medial to the radial shaft proximally, and anterior to it distally. Runs inferolaterally under cover of brachioradialis and distally lateral to flexor carpi radialis tendon; Its posterior relations in the forearm are successively the tendon of biceps, supinator, the distal attachment of pronator teres, the radial head of flexor digitorum superficialis, flexor pollicis longus, pronator quadratus and the lower end of the radius (where its pulsation is most accessible).

Winds around lateral aspect of radius and crosses floor of anatomical snuff box to pierce fascia; ends by forming deep palmar arch with deep branch of ulnar artery.

Branches in the forearm

- Radial recurrent artery
- Cutaneous branches & Muscular branches.

Ulnar artery

The ulnar artery is the larger terminal branch of the brachial artery. It starts 1cm distal to the flexion crease of the elbow and reaches the medial side of the forearm midway between elbow and wrist.

Passes inferomedially and then directly, deep to pronator teres, palmaris longus, and flexor digitorum superficialis to reach medial side of forearm. The ulnar artery crosses the flexor retinaculum lateral to the ulnar nerve and pisiform bone to enter the hand and gives a deep palmar branch to deep arch and continues as superficial palmar arch. The ulnar nerve lies medial to the distal two-thirds of the artery.

Branches in the forearm

- Anterior and posterior ulnar recurrent arteries
- Common interosseous artery
- Anterior interosseous artery
- Muscular and nutrient branches

Radial recurrent artery

Originates on the lateral side of radial artery, just distal to its origin.

Ascends on supinator and then passes between brachioradialis and brachialis. It supplies these muscles and the elbow joint, anastomosing with the radial collateral branch of the profunda brachii.

Anterior ulnar recurrent and posterior ulnar recurrent artery.

Originates from ulnar artery, just distal to elbow joint.

AUR artery ascends between brachialis and pronator teres, supplies them and anastomoses with the inferior ulnar collateral artery anterior to the medial epicondyle.

PUR artery passes dorsomedially between flexores digitorum profundus and superficialis, ascending behind the medial epicondyle; it supplies adjacent muscles, nerve, bone and elbow joint, and anastomoses with the ulnar collateral and interosseous recurrent arteries.

Common interosseous artery

The common interosseous artery is a short branch of the ulnar artery.

After a short course, terminates by dividing into anterior and posterior intersosseous artery.

Anterior interosseous artery

The anterior interosseous artery descends on the anterior aspect of the interosseous membrane with the anterior interosseous branch of the median nerve.

The anterior interosseous artery proper leaves the anterior compartment by piercing the interosseous membrane proximal to pronator quadratus. It anastomoses with the posterior interosseous artery in the posterior compartment of the forearm.

Posterior interosseous artery

It passes dorsally between the oblique cord and proximal border of the interosseous membrane. It descends deep in the groove between extensor carpi ulnaris and the extensor digiti minimi part of extensor digitorum. While in the groove it gives rise to multiple muscular branches. The posterior interosseous artery accompanies the deep branch of the radial nerve (posterior interosseous nerve) on abductor pollicis longus. Distally it anastomoses with the terminal part of the anterior interosseous artery and the dorsal carpal arch.

NERVES OF FLEXOR COMPARTMENT [6]

The lateral cutaneous nerve of the forearm, the cutaneous continuation of the musculocutaneous nerve, pierces the deep fascia above the elbow lateral to the tendon of biceps and supplies the anterolateral surface of the forearm.

The medial cutaneous nerve of the forearm supplies front and back of the medial part of the forearm.

The posterior cutaneous nerve of the forearm passes along the dorsum of the forearm to the wrist. It supplies the skin along its course

Median Nerve[6]

Enters the forearm between the heads of pronator teres. It passes behind a tendinous bridge between the humero-ulnar and radial heads of the flexor digitorum superficialis, and descends through the forearm posterior and adherent to flexor digitorum superficialis and anterior to flexor digitorum profundus. About 5 cm proximal to the wrist it becomes superficial. It then passes deep to the flexor retinaculum into the palm.

Branches in the forearm

• Anterior interosseous nerve

• Muscular branches to pronator teres, flexor carpi radialis, palmaris longus and flexor digitorum superficialis.

• Articular branches.

Ulnar Nerve[6]

The ulnar nerve enters the forearm from the extensor compartment of arm by passing between the two heads of flexor carpi ulnaris.The ulnar nerve descends on the medial side of the forearm, lying on flexor digitorum profundus with the ulnar artery to its radial side.

It supplies flexor carpi ulnaris and ulnar half of flexor digitorum profundus also gives palmar cutaneous branch

Superficial terminal branch

The superficial terminal branch of the radial nerve, the cutaneous continuation of the main nerve, runs from the cubital fossa on the surface of supinator, pronator teres tendon and flexor digitorum superficialis, on the lateral side of forearm under cover of brachioradialis. In the middle third of the forearm it lies beside and lateral to radial artery. It then leaves the flexor compartment of the forearm by passing backwards deep to the tendon of brachioradialis and breaks into two or three branches.

Nerve of extensor compartment:

Posterior interosseous nerve:

The posterior interosseous nerve is the deep terminal branch of the radial nerve. It reaches the back of the forearm by passing round the lateral aspect of the radius between the two heads of supinator. It passes downwards over the abductor pollicis longus origin and dips down to reach the interosseous membrane were it passes between the muscles as far as the wrist joint. Here it ends in a small nodule from which branches supply the wrist joint.

Branches in the forearm

Muscular branches to all muscles which arise from the common extensor origin and deep muscles of the extensor compartment.

BIOMECHANICS[9]

The longitudinal axis of rotation of the forearm passes through the articular surface of the radial head, the interosseous membrane, and the articular surface of the ulna at the distal radio-ulnar joint.[8]

Diaphyseal fractures of the radius and ulna present specific problems in addition to those common to all fractures of the shafts of long bones. In addition to regaining length, apposition and axial alignment, achieving normal rotational alignment is necessary if a good range of pronation and supination are to be restored.

The movements of supination and pronation of the forearm involve a rotatory movement around a vertical axis at the proximal & distal radioulnar joints. The axis passes through the head of radius above and the attachment of apex of the triangular articular disc below. During pronation, the entire radius moves around the ulna through the longitudinal axis of forearm.

Pronation is performed by pronator teres and pronator quadratus. Supination is performed by biceps brachiaii and supinator. Supination is the powerful of the two movements, because of the strength of biceps muscle. Maintenance of the interosseous space is essential for pronation and supination. The biceps and the supinator exert rotational forces on fractures of the proximal third of radius. Distally, the pronator teres at the level of mid shaft and the pronator quadratus on the distal fourth of shaft of radius exert both rotational and angulatory forces. Fractures of distal radius tend to angulate toward the ulna by the action of the pronator quadratus and the pull of long forearm muscles.

Rotational deformity will limit radioulnar movement. The supinator muscles are inserted proximally and the pronators distally. Consequently in a fracture of mid shaft of radius the proximal fragment supinates and the distal fragment pronates, resulting in 90˚ of rotational displacement. Shortening of the two bones following overriding may also occur. Both angular and rotational deformities are compounded by the presence of comminution. Hence, in addition to regaining length, bony apposition, axial alignment and achieving normal rotational alignment is necessary, if a good range of pronation and supination are to be restored.

CLASSIFICATION

Fractures of forearm are classified according to the level of fracture, the pattern of fracture, the degree of displacement, the presence or absence of comminution or segmental bone loss and whether they are open or closed. Each of these factors may have some bearing on the type of treatment to be selected and the ultimate prognosis. For descriptive purposes, it is useful to divide the forearm into thirds, based on the linear dimensions of radius and ulna. Disruption of proximal or distal radioulnar joints is of great signifance to the treatment and prognosis. It is imperative to determine whether the fracture is associated with joint injury because effective treatment demands that both the fracture and joint injuries are treated in an integrated fashion.

AO CLASSIFICATION[10]

Type	22 A	Simple fractures of one or both bones
	A1	Simple fracture of ulna
	A2	Simple fracture of radius
	A3	Simple fracture of both radius & ulna
Type	22 B	Wedge fractures of one or both bones
	B1	Wedge fracture of ulna
	B2	Wedge fracture of radius

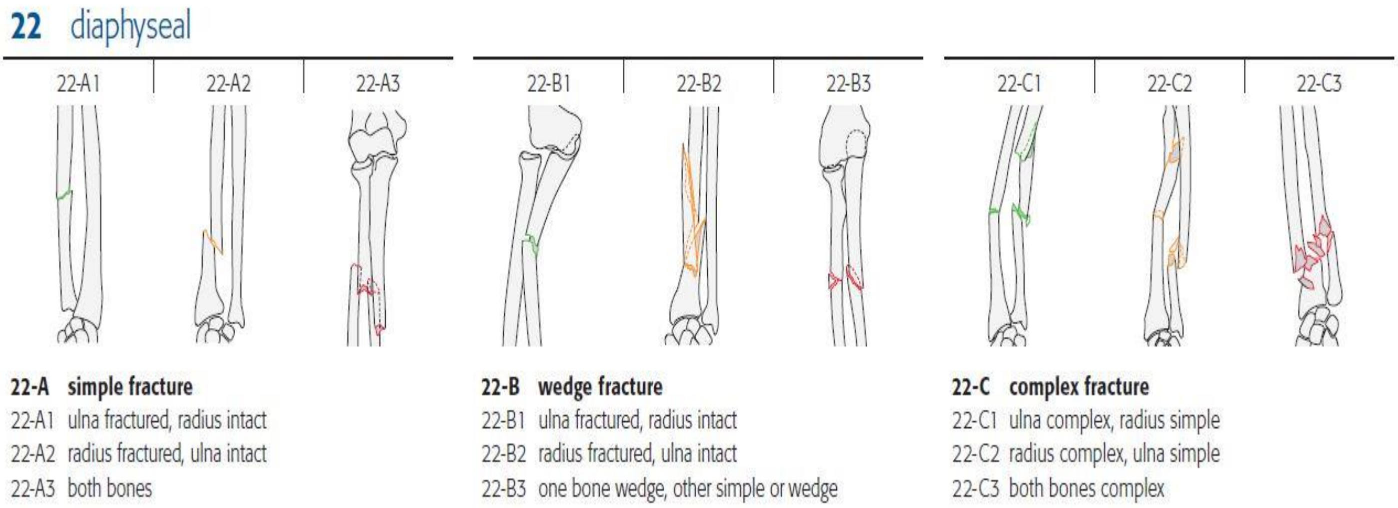
B3 Wedge fracture of both radius & ulna

Type 22 C Complex fracture of one or both bones

C1 Grossly comminuted fracture of ulna with simple fracture of radius

C2 Grossly comminuted/segmental fracture of Radius with simple fracture of ulna

C3 Grossly comminuted fractures of both bones



MECHANISM OF INJURY[11]

The mechanisms of injury that causes fractures of the radius and ulna are myriad. By far the most common is some form of vehicular accident, especially automobile and motor cycle accidents. Most of these vehicular accidents result in some type of direct blow to the forearm. Other causes of direct blow injuries include fights in which one of the adversaries is struck in the forearm with a stick or rod. The person throws the forearm upto protect his or her head, and the forearm is the recipient of the violence. Following violent twisting of forearm, rotational deforming forces act leading to fracture of forearm bones.

Gunshot wounds can cause fractures of both bones of forearm. Such injuries are commonly associated with nerve or soft tissue defects and frequently have significant bone loss. The other common mechanism is due to some type of fall. The force generated is usually much greater than that required to cause Colle's fracture. Most forearm shaft fractures resulting from fall occur in the athletes or in fall from heights.

The last and least common cause of diaphyseal fractures of both bone forearm is due to pathological fractures.

INVESTIGATIONS[18]

A minimum of two views – anteroposterior and lateral – are mandatory in all suspected forearm fractures. Additional oblique views may be required. The following features are noted in the radiographs.

1) Degree of offset

2) Degree of angulation

3) Amount of shortening

4) Presence of comminution

Additional visualization is needed to rule out involvement of wrist, elbow and both radioulnar joints. A line drawn through the radial shaft, neck and head should pass through the center of the capitellum on any projection.

The rotational alignment of the forearm is difficult to determine in routine antero posterior and lateral views. The bicipital tuberosity view recommended by Evans is helpful in those instances. Since the proximal radial fragment could not be controlled with closed methods, the distal radial fragment must be brought into correct relationship with the proximal fragment. Ascertaining the rotation of the proximal fragment from the tuberosity view before reduction, gives some idea of how much pronation or supination of distal fragment is needed. The tuberosity view is made with the x-ray tube tilted 20˚ towards the olecranon, with the subcutaneous border of ulna flat on the cassette. The x-ray can then be compared with the diagram showing the prominence of the tubercle in various degree of pronation and supination. As an alternative, a film of the opposite elbow can be made in a given degree of rotation for comparison.

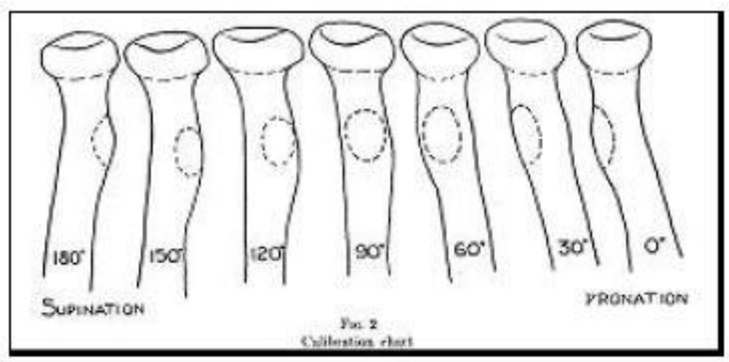


Fig. 2
Calibration chart

Xray Images of Radial tuberosity at different levels of fracture.

PRINCIPLES OF MANAGEMENT

There are a number of factors which play a dynamic role in determining the type of management, thereby influencing the prognosis. They include:

1) Amount of overriding of fracture fragments

2) Degree of Comminution

3) Extent of soft tissue injuries

4) Associated neuro vascular injuries

5) Magnitude of joint involvement

6) Presence of multiple trauma

7) The width of medullary canal

8) Degree of osteoporosis

9) Complex ipsilateral injuries (side swipe injury)

So the objectives of treatment of diaphyseal fractures of both bones in adults are:

1) To obtain and maintain satisfactory reduction and rigid fixation.

2) To regain functional range of movement of elbow joint.

3) To regain adequate pronation and supination

4) To treat associated injuries.

The absence of pronation and supination is a permanent handicap since they cannot be regained by physiotherapy or rehabilitation.

METHODS OF TREATMENT[10]

There are a variety of options for treating an adult with a fracture of both bones of forearm. It is fair to say that the vast majority of fractures of both bones of the forearm can be most effectively treated by accurate anatomical reduction, rigid plate fixation, and early mobilization. The various modalities of treatment available for treating adult diaphyseal fractures of both bones of forearm are:

1) Conservative Management:

a) Cast Immobilization \

b) Closed reduction and cast immobilization

2) Surgical Management:

a) Open reduction and internal fixation with plate osteosynthesis

b) Closed reduction and Intramedullary fixation

c) External fixator application

CONSERVATIVE MANAGEMENT[10]

a) Cast Immobilization:

The rare non displaced fracture of both bones of the forearm in adults can usually be treated by immobilization in above elbow cast with elbow in 90˚ flexion and forearm in midprone position. Angulation can be prevented by incorporating a plaster loop on the radial side of the cast proximal to the level of fractures. Despite good technique, an initially non displaced fracture can become displaced while being immobilized in plaster.

b) Closed reduction & Cast immobilization:

It is difficult to reduce and maintain satisfactory position of the fragments by closed methods due the various deforming forces acting on the fragments and due to the role of supinators and pronators leading to rotatory instability. Closed reduction is most successful for fractures of both radius and ulna when the fractures are located in distal third. Functional cast bracing of forearm fractures following 6 weeks of immobilization in arm cast helps in starting early elbow mobilization exercises leading to lesser incidence of elbow stiffness. Before closed reduction is undertaken, the patient must be advised that, surgical fixation may be necessary at any time to ensure solid union in acceptable position.

Technique of closed reduction[14]

Relaxation of muscles is mandatory for closed reduction and general anesthesia is preferred. Tuberosity view is taken with image intensifier to identify the degree of rotation. Traction and counter traction are applied and ulna is reduced under direct palpation. The radius could not be palpated in the proximal half. The forearm is placed under appropriate supination as determined by the tuberosity view. When the fractures seem reduced and the alignment of forearm appears satisfactory, an above elbow plaster slab is applied and check X-rays are taken. Above elbow cast conversion is done after 1 week and radiographs in two planes are taken at weekly intervals through the cast for the first month and every two weeks thereafter until solid union is obtained.

There are only a few indications available for conservative treatment in adult forearm fractures. These include

1) Undisplaced/ incomplete fractures
2) Associated life threatening trauma like head injury, chest injury etc.

SURGICAL MANAGEMENT

INTRODUCTION:

During the last century, surgical management of diaphyseal fractures of both bones forearm in adults has gained widespread acceptance as operative techniques and the quality of implants have improved. The combination of properly designed implants, better understanding of the personality of the fracture, minimal soft tissue handling techniques, preoperative antibiotics have made surgical fixation safe and practical while treating these fractures.

The goals of operative treatment for diaphyseal forearm bones fractures in adults include

a) Anatomical alignment

b) Stable fixation

c) Early mobilization

d) Early functional rehabilitation of upper limb.

Indications for operative management include virtually all diaphyseal fractures of both bones of forearm in adults.

Open Reduction and Internal fixation: [10]

An AO dynamic compression plate (Asian) with 3.5 mm screw system provides for secure fixation without cast protection. In an adult, fixation by semitubular plate does not provide with a rigid fixation. Plates are especially useful in fixation of fractures of distal 3rd or proximal 4th of both bones of forearm.

a) Principles:

- Plate osteosynthesis provides for static compression at the fracture site.
- Plates should be applied on the tension side of bones whenever possible.
- For both radius and ulna, dorsal side is the tension side.
- Minimal stripping of periosteurn from ends of fracture fragments.
- Both radius and ulna has to be fixed with similar type of implant.
- Autologous bone graft is added whenever there is comminution involving more than 1/3rd of circumference of bone.
- Before plate application, larger comminuted fragments should be secured to the main fragments to produce interfragmentary compression.
- Fractures of both radius and ulna should be exposed and reduced temporarily before a plate is applied to either.

- Plates must be accurately centered over the fracture site and there must be a minimal of six cortical purchases with screws on either side of fracture.
- If autologous bone graft is added, they should not be placed in the interosseous border, else cross union may occur.

b)Technique of fixation:

RADIUS

Approach:[12]

- for proximal half, dorsal Thompson's approach
- for distal half, anterior Henry's approach
- for mid 3rd, either of the approaches may be used.
- minimal stripping of periosteum is done to preserve blood supply
- Clear away all the clotted blood from the ends of the bone
- All soft tissue attachments of the comminuted fragments should be retained, if possible
- Reduce the fracture as anatomically as possible fitting any butterfly fragments into position
- Larger butterfly fragments should be fixed to the main fragment by lag screw principle

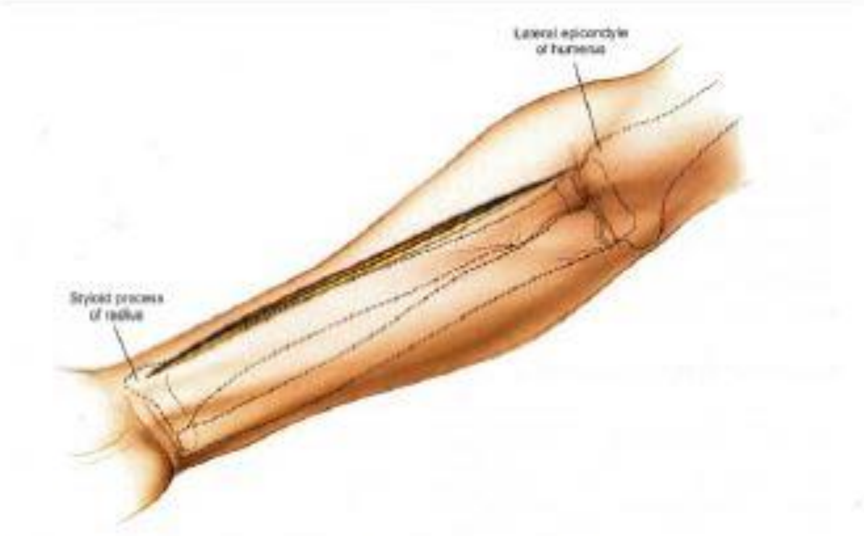
- An Asian DCP, usually a 6 or 7 holed plate is selected in accordance with the fracture pattern and applied over radius
- A 2.7 mm drill bit is used to drill hole in the radius, and then tapped. An appropriate sized 3.5 mm cortical screw is measured with depth gauge and used to fix the plate to the bone
- Always drill one hole at a time and insert screw before drilling the next screw
- Similarly all the 6 or 7 holes of the plate are drilled and fixed with screws.
- Autologous bone graft is added if the comminution involves more than one third of the circumference of radius.

ULNA[12]

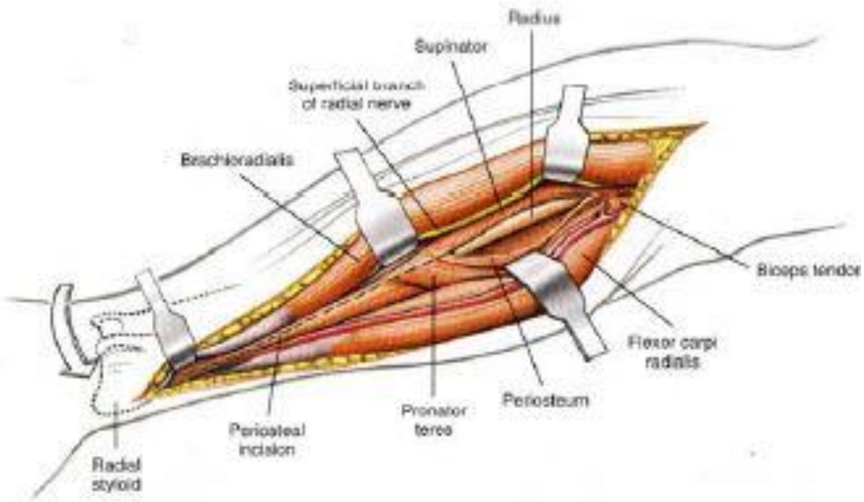
Approach

- Incision along subcutaneous border of ulna.
- Plate is fixed on either anterior or posterior surface on which it fits best.
- Posterior surface is better since it is the tension side of ulna
- If there is comminution, place the plate on the side of comminution since it stabilizes the loose fragments.
- Add autologous bone grafts if needed.

<u>Volar Henry Approach</u>

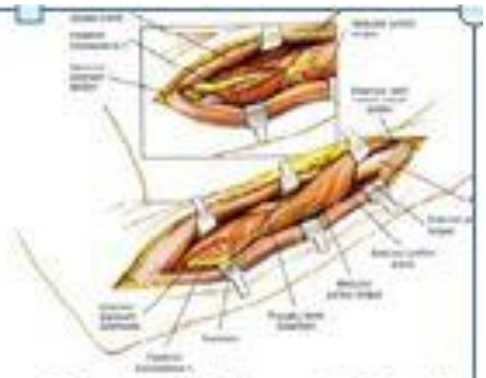


Make a straight incision on the anterior part of the forearm, from the flexor crease on the lateral side of the biceps down to the styloid process of the radius.

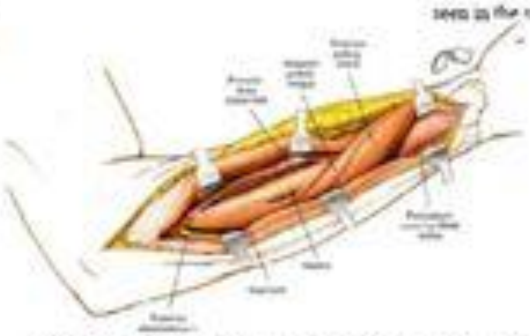


Turn the arm downward to identify the pronator teres muscle. Resect it along its insertion on the lateral aspect of the radius.

Posterior Thompson Approach to Radius



The supinator cloaks the upper third of the radius; t
posterior interosseous nerve runs through
substance. The nerve must be protected and identifi
as it traverses the muscle. The interosseous nerve
seen in the substance of the supinator (inset).



Detach the insertion of the supinator from the anterior aspect of the radius, with the arm in full supination to bring the origin of the supinator into view and to move the posterior interosseous nerve away from the area of incision. This uncovers the lateral border of the radius.

-

Closed intramedullary nail fixation[13]

While selecting an intramedullary device, it is mandatory to select a nail of appropriate diameter for fixation. If the size of the nail is small, there is side to side and rotatory movement leading to instability. If the size of the nail is large, further comminution or additional fracture may occur.

Principle:[13]

- Since the fractures of both radius and ulna are fixed in closed manner, fracture hematoma is preserved leading to early union and consolidation. Moreover, the chance of infection is minimized.
- The ulna is fixed first
- An appropriate sized nail is selected, so that the nail fits snuggly inside the medullary canal.
- Titanium elastic nail offers three point fixation thereby stabilizing the fracture fragments.

Technique of fixation[13]

- C arm is mandatory

- Closed reduction of the bones is achieved with traction, counter traction and manipulation
- The reduction is checked with C arm.
- For the ulna, entry point in made over the olecranon with an awl and the position is confirmed
- A nail is introduced through the olecranon and passed across the fracture site under image control
- For the radius – the entry point is from distal aspect and three entry points are described
  - (a) just medial to Lister tubercle
  - (b) just lateral to Lister tubercle
  - (c) from radial styloid
- All 3 entry points are made 5 mm proximal to wrist joint.
- The entry point that is just medial to Lister's tubercle is the most preferred.
- The nail is passed, across the fracture site under C arm control.

Titanium elastic nail[13]

- Both the radius and ulnar nails are cut at their ends and buried

IMPLANT REMOVAL

Plates & screws and intramedullary nails placed on forearm bones are not removed routinely unless they cause symptoms. In any case they should not be removed before 2 years, even though the fracture will have appeared solid on radiographs much earlier. The limb has to be protected in above elbow slab for minimum 6 weeks after removal, if there is local pain or tenderness .

COMPLICATIONS[11]

The complications following operative treatment for diaphyseal fractures of both bones forearm in adults are relatively less common because of better surgical techniques and improved implants.

Complication of fractures:[11]

(a) Infection

(b) Malunion

(c) Non union

(d) Cross union

(e) Associated vascular and nerve injuries

(f) Post traumatic Stiffness

Complication of operative treatment

(a) Incomplete reduction

(b) Incongruous reduction

(c) Unstable fixation

(d) Inadequate implant

(e) Infection.

The use of state of the art implants and instrumentation for diaphyseal fractures of both bones forearm does not always guarantee a favourable outcome. The surgeon must have a thorough understanding of local anatomy, mechanics of fracture fixation and patterns of fracture healing after internal fixation if consistently good results are to be achieved.

Infection[11]

The major drawback of operative fixation is infection. It is less common with closed intramedullary fixation than with open reduction techniques. If post operative infection develops, appropriate antibiotics are given for 3 to 6 weeks intravenously. Even in the presence of infection, every effort should be made to retain the implants since stable infected fractures are easy to manage than unstable infected fractures. However if the infection is severe, the implant has to be removed.[11]

Malunion[11]

This is relatively more common in conservatively treated cases than in surgically treated cases, since it is difficult to maintain the fracture fragments in alignment when treated conservatively. The varying pull of supinators and pronators on the fracture fragments lead to malunion.

Non union[11]

The varying causes of nonunion are inadequate immobilization, improper fixation, implant failure and the presence of underlying infection. Gross osteoporosis of the bones is also an important cause for nonunion. Inadequate internal fixation, with plates which are too small, nails which are of inappropriate size is a potent cause of nonunion. Loss of substance of radius or ulna following gun shot injuries also lead to nonunion. Repeated manipulation by traditional bone setters may also lead to nonunion. In a case of non union, open reduction and internal fixation with autologous bone grafting is the treatment of choice.

Cross union[11]

Cross union of the radius and ulna results from a continuous hematoma between the two fractures. The important cause of cross union following conservative treatment is improper reduction with bony fragments encroaching the interosseus space. Cross union may also occur if the fractures are stabilized by open methods and bone grafting with bone grafts kept in the interosseous border of either bones. If cross union occurs there is loss of pronation and supination due to a bridge of bone between radius and ulna. This bridge of bone has to be excised for pronation and supination to occur.

Synostosis is relatively uncommon. Seen frequently in patients with either a crushing injury of forearm or a head injury. The highest risk for synostosis is in proximal fractures treated through single incision. If synostosis develops and position of forearm is relatively functional,it is best to do nothing. if rotational alignment of forearm is poor, an osteotomy to position the hand in more functional position can be considered.

Post traumatic stiffness

This is more common is patients managed conservatively than by surgical fixation. Elbow joint is notorious for developing stiffness if it is immobilized too long. The main advantage of surgical fixation is that, since the fracture fragments are stable after fixation, active mobilization exercises of wrist, elbow and hand can be started early.

Nerve injuries[11]

Injury to posterior interosseous nerve can occur in Henry's approach during plating of radius. Also, there are chances of injury to recurrent radial artery and superficial branch of radial nerve through this approach. These can be prevented by knowing the proper anatomy of forearm and gentle handling of soft tissues.

Compartment syndrome[11]

This can occur either after trauma or after surgery on the forearm bones. They are usually due to faulty hemostasis or closure of the deep fascia. They can usually be avoided by releasing the tourniquet before wound closure to make sure hemostasis is adequate, by closing only the subcutaneous tissue and skin.

Complications of intramedullary nail fixation:

Most complications result from improper selection of nail size. A nail that is too long may be driven through the bone end. One that is too short may not adequately stabilize the fracture. A nail with too large a diameter may split the cortex and one with a smaller diameter may not adequately control rotational alignment resulting in non-union.

IMPLANT PROFILE

DYNAMIC COMPRESSION PLATE 3.5 MM[15,16]

DCP is now the workhouse of AO system. When introduced in 1965 it was made of Titanium, but it is now fabricated from 316 stainless steel (Zimmer) and of Vitallium (Howmedica).[15]

The DCP of AO.ASIF consists of a plate with obliquity of cylindrical screw holes for compression which is produced as the screws are driven home. Due to this mechanism, use of a tension device is not required. This has made the plate more adaptable to different situation of internal fixation and can be used as a static compression plate, a buttress plate, a neutralization plate or as DCP.[16]

These plates are used with cortical screws of size 3.5mm, hence the name. The holes allow for 1mm displacement if a load screw is used, thereby producing compression. The plate can be used with an articulated tension device. The oval holes permit eccentric position of screws which can be used for axial compression.

Important dimensions:

a) Thickness 3 mm

b) Width 10 mm

c) Hole spacing 12mm and 16 mm

d) Hole length 6.5mm

e) Length 25mm to 145 mm

f) Holes 2 to 12

AO stainless steel implants are produced from implant quality 316L stainless steel which typically contains iron 62.5%, chromium 14.5%, nickel 2.8%, molybdenum and minor alloy elements.

ONE THIRD TUBULAR PLATES

These plates have the form of one third of the circumference of a cylinder. They have low rigidity since they are only 1 mm thick. The plate is fixed with 3.5 mm cortical screw. They do not produce compression at fracture site

Important dimensions

Thickness	1 mm
Width	9 mm
Hole spacing	12 mm and 16 mm
Length	25 mm to 145 mm
Holes	2 to 12

3.5 mm CORTICAL SCREW:

The holding power of the cortical screw on dense cortical bone is due to its 1.75mm pitch and the asymmetrical buttress threads.

Important Dimensions:

Head diameter	6mm
Hexagonal socket width	2.5 mm
Core diameter	2.4 mm
Thread diameter	3.5 mm
Pitch	1.75 mm
Length	10 mm – 110 mm

TITANIUM ELASTIC NAIL

These nails are made of alloys such as Ti-6Al-7Nb. They offer outstanding corrosion resistance, excellent biocompatibility and higher strength. Titanium alloy implants may be ceramic shot peened and either chemically panivated in nitric acid or anodized as a final surface treatment.

Implant profile

Length	:	44 cm
Width	:	2 mm to 5 mm
		Color coded for different sizes
End	:	Beak shaped for easy insertion and may be used as a reduction tool.

IMPLANTS

PLATE OSTEOSYNTHESIS

TITANIUM ELASTIC NAIL

EVALUATION OF OUTCOME[17]

For evaluating the functional outcome of fracture fixation, we used the MODIFIED GRACE AND EVERSMANN SCORING SYSTEM. This system takes into account the following parameters:

1. SUPINATION AND PRONATION[17]

(Normal – pronation & supination 80 degrees each)

RATING	RANGE OF MOVEMENT	SCORE
EXCELLENT	> 80	4
GOOD	60 TO 80	3
FAIR	40 TO 60	2
POOR	< 40	1

2. RADIOLOGICAL UNION (End of 6th week)

RADIOLOGICAL UNION	SCORE
UNION PRESENT (good callus)	2
NON UNION	1

3. RANGE OF MOVEMENT – ELBOW[17]

Range	Result	Score
Flexion > 120	**Excellent**	**4**
Flexion 100 to 120	**Good**	**3**
Flexion 80 to 100	**Fair**	**2**
Flexion < 80	**Poor**	**1**

Final Analysis

RESULT	SCORE
EXCELLENT	10 and above
GOOD	8 to 9
FAIR	6 to 7
POOR	Less than 5

PART- B

PREAMBLE

The diaphyseal fractures of both bone fractures of forearm is one of the most common fracture pattern occurring in adults. These fractures are routinely fixed by plate osteosynthesis with 3.5 mm Asian DCP efficiently and successfully. Since this system is of load bearing type which necessitates distruption of fracture hematoma during fixation, the choice of intramedullary nail fixation for forearm fractures comes into play.

This series includes 20 cases (10 cases of plate osteosynthesis, 10 cases of titanium elastic nails), all of whom were adults. The diaphyseal fractures of both radius and ulna were selected. The outcome was analysed with special emphasis on rotatory stability at the fracture site and time taken for full range of motion to occur.

Based on our findings we hereby submit **"Fractures of both bones forearm – A comparative study on fixation techniques and functional outcome between Intramedullary Nailing and Plate osteosynthesis".**

AIM OF STUDY

Even though fractures of both bones of forearm is one of the most common fractures occurring in adults, they are also one of the most common fractures to be mismanaged. Even today most of these fractures are treated by traditional bone setters leading to increased morbidity and infection.

Traditionally, these fractures are treated by plate osteosynthesis using AO Dynamic compression plate (Asian) very efficiently. The aim of our study is to compare the functional outcome of fixation of both bones of forearm using plate osteosynthesis with that of Titanium elastic nail.

This study aims to stress the need for rigid fixation of forearm fractures and to evaluate the early restoration of movements of wrist, elbow and forearm.

MATERIALS AND METHODS

Design of the study :Prospective study

Period of study : September 2012 – September2014

This is a prospective study of 20 cases of diaphyseal fractures of both bone of forearm in adults treated by surgical fixation with Plate and titanium elstic nail.

The period of surgery and follow up extends from September 2012 to September 2014. It includes all diaphyseal fractures of both bones of forearm in adults. Comminuted, segmental fractures are included in this study. All compound fractures, malunited fractures, bones with medullary canal diameter of less than 2mm and fractures in children are excluded from this study.

Inclusion Criteria :

1. Diaphyseal fractures of both bones of forearm in adults >18 years
2. Comminuted and segmental fractures of forearm
3. Patients fit for surgery

Exclusion Criteria :

1. Compound fractures
2. Malunited fractures
3. Bones with narrow medullary canal < 2 mm in diameter
4. Patients unfit and not willing for surgery

The cases were analysed as per the following criteria

1) Age distribution
2) Sex distribution
3) Side of injury
4) Mode of injury
5) Classification of fracture
6) Time interval between injury and surgery
7) Associated injures
8) Complications
9) Additional procedures for complications
10) Duration between injury and hospitalization

Imaging[18]

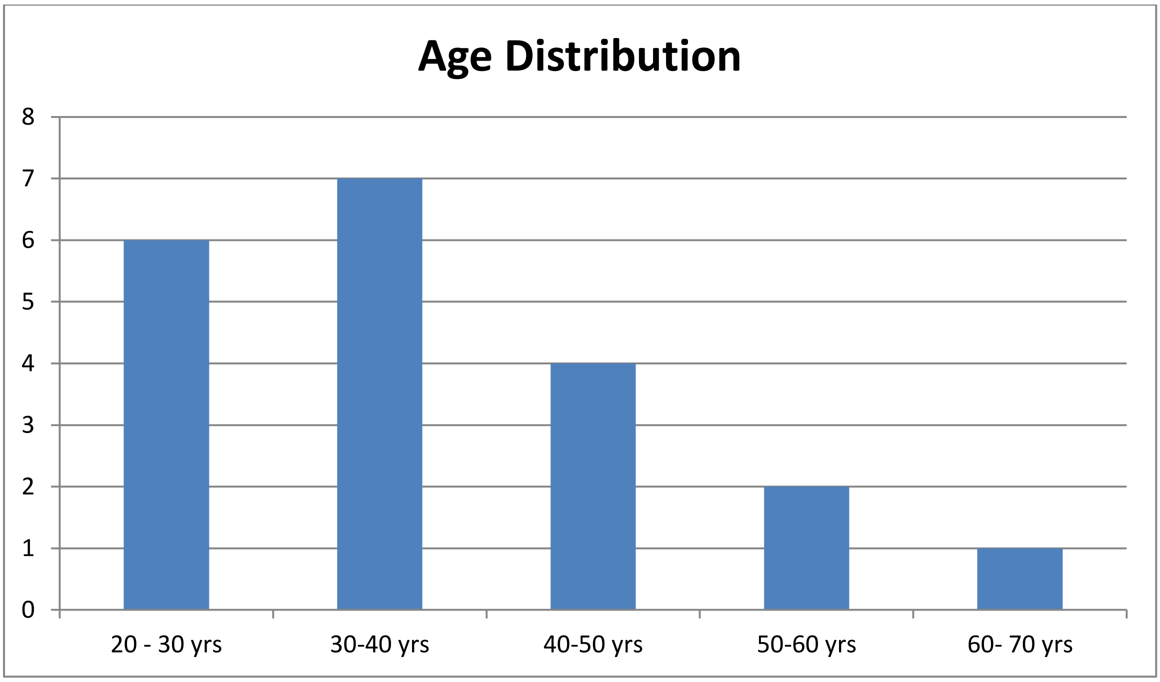
The clinical signs and symptoms are usually obvious in shaft fractures of both bones of the forearm, so are the radiologic signs. The configuration of midshaft fractures of the radius and ulna varies depending on the mechanism of injury and the degree of violence involved. Low-energy fractures tend to be transverse or short oblique, whereas high-energy injuries are frequently extensively comminuted or segmented, often with extensive soft tissue injuries.

Radiographs of the radius and ulna i. e., anteroposterior and lateral views, were obtained. The elbow and wrist joints were included in each view.

I. AGE DISTRIBUTION:

The age group varied from 20 years to 70 years with the mean age of 45 years. Incidence of fracture was observed maximum between 30-50 years of age.

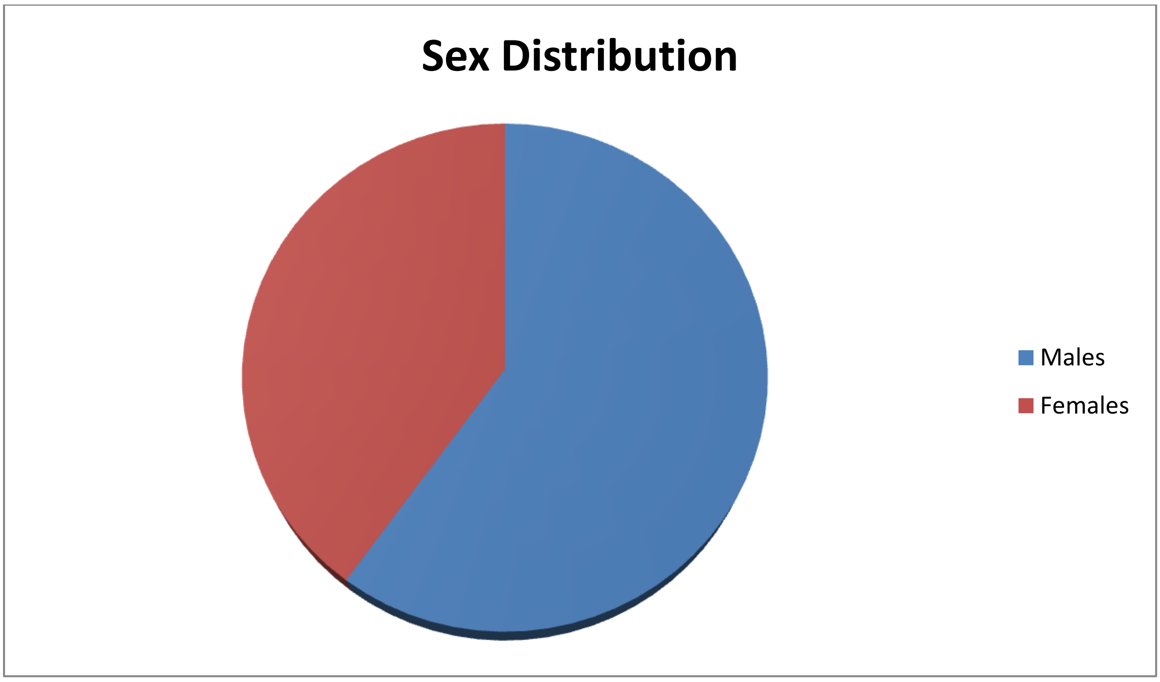
Age Group	Number of cases	Percentage
20 – 30 years	6	30
30 – 40	7	35
40 – 50	4	20
50 – 60	2	10
60 – 70	1	5



II. SEX DISTRIBUTION:

Among the 20 cases, males were predominant

Sex	Number of cases	Percentage
Male	12	60
Female	8	40

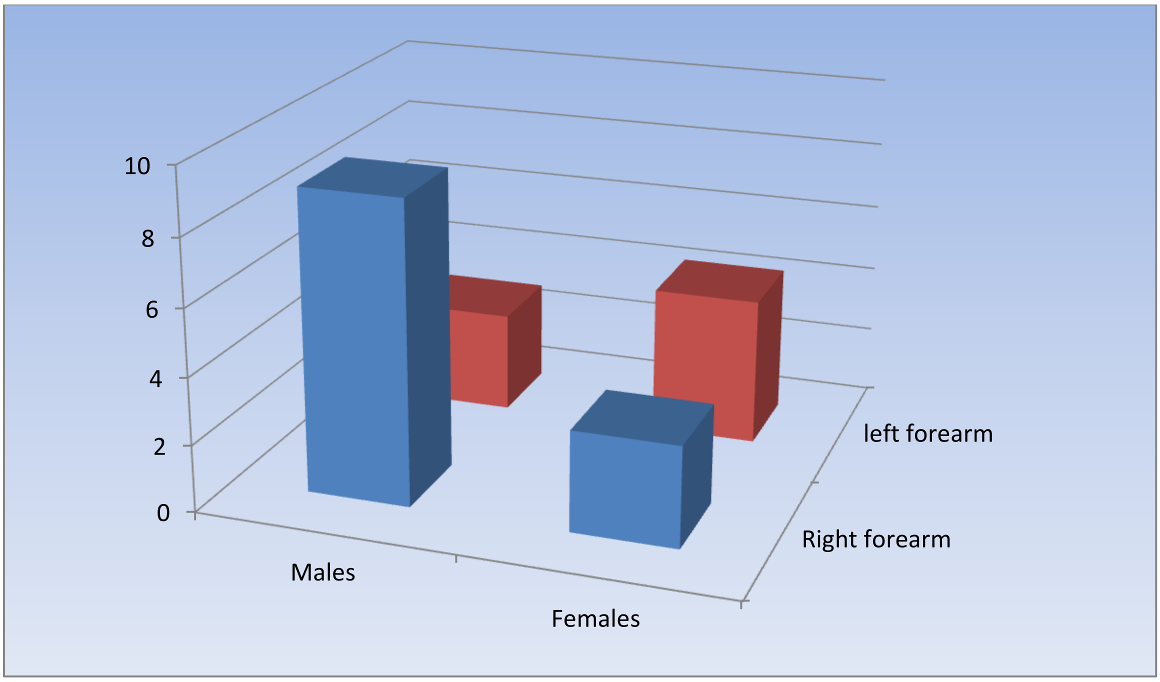


III. Side of Injury:

Right side was common in our series

Sex	Right	Left	Bilateral	Total
Male	9	3	-	12
Female	3	5	-	8
Percentage	60	40	-	-

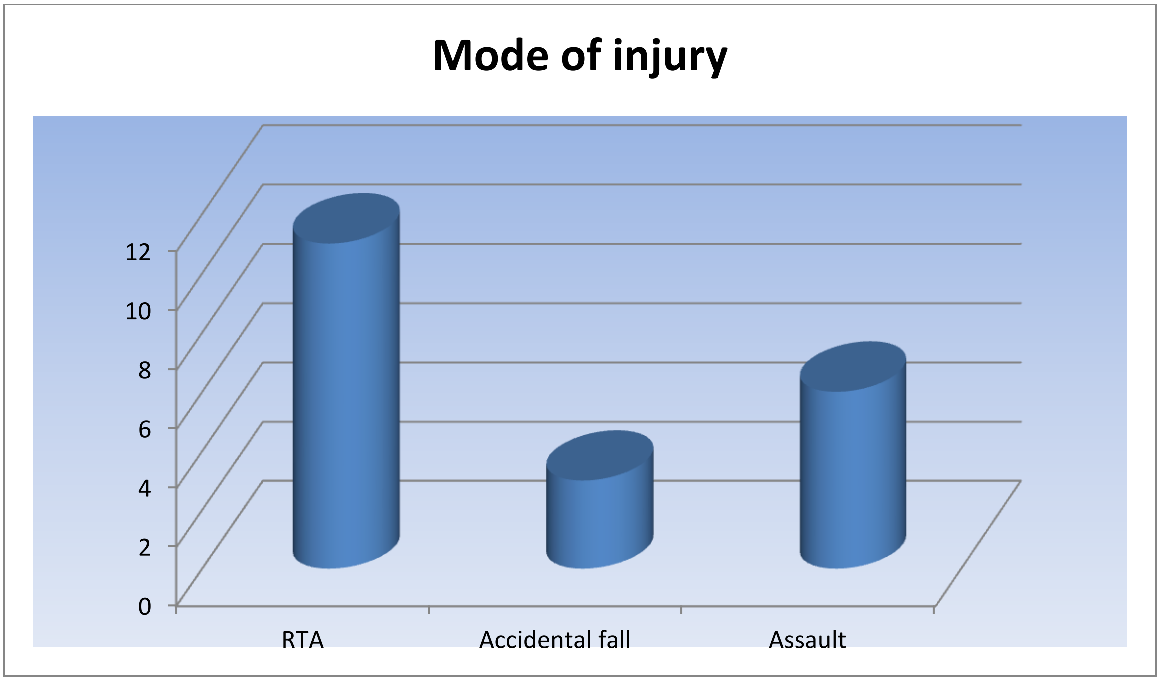
Side distribution



IV. Mode of Injury

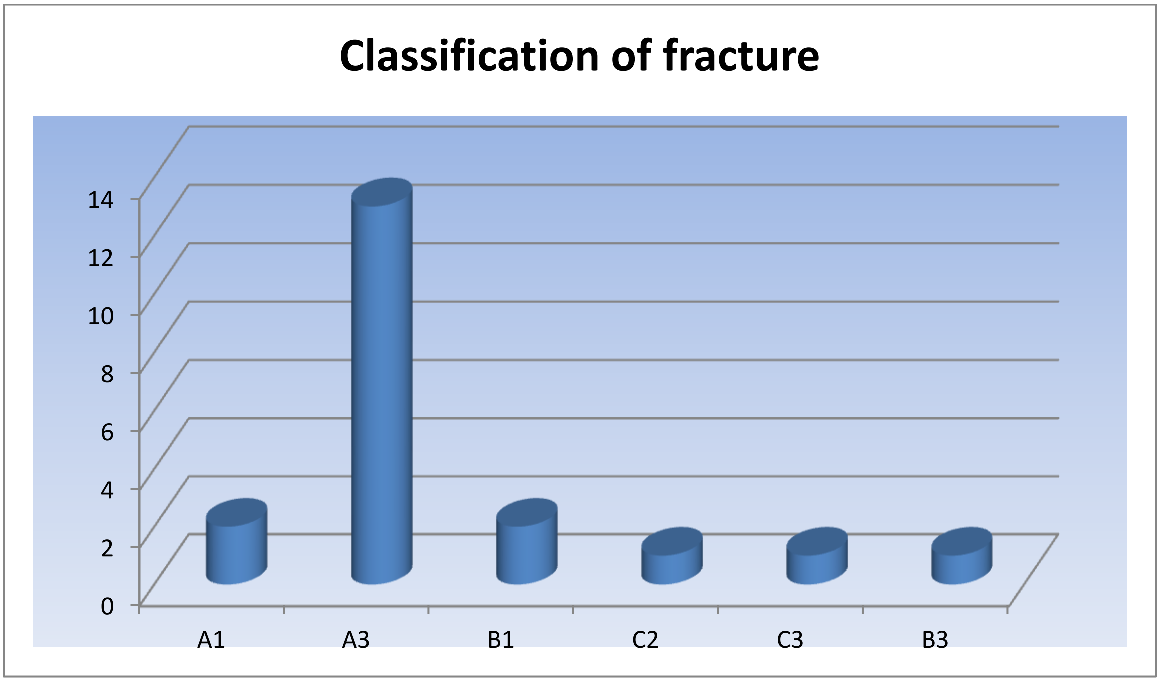
Commonest mode of injury had been road traffic accident.

Mode of Injury	No. of cases	percentage
RTA	11	55%
Fall	3	15%
Assault	6	30%



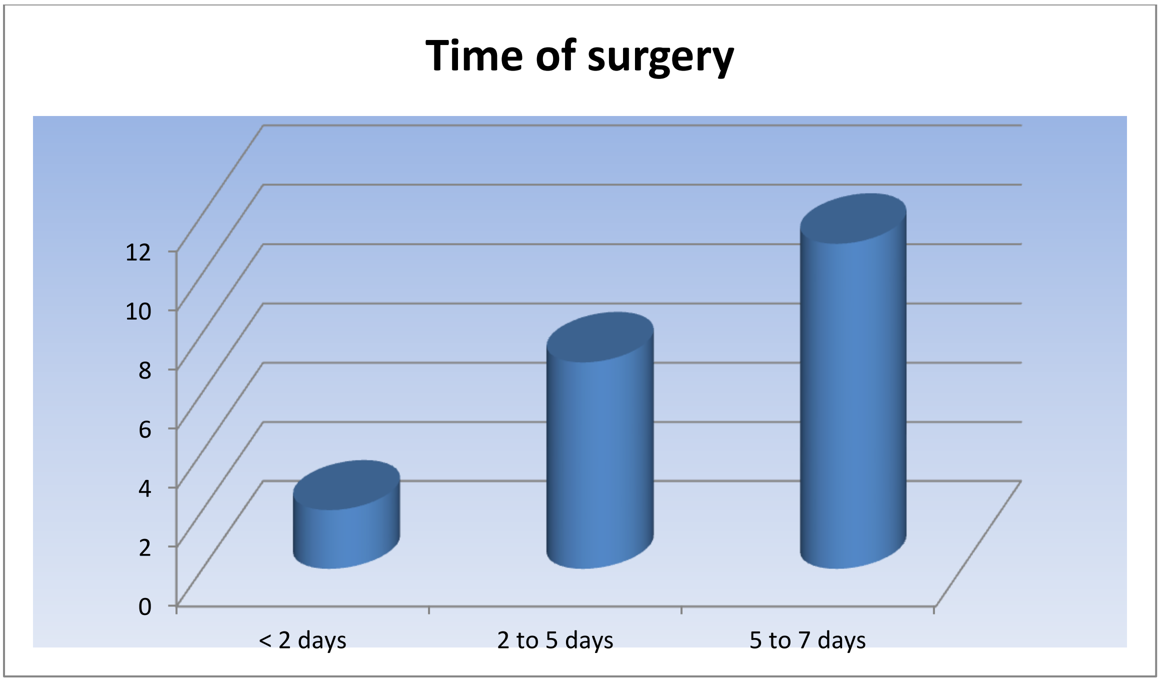
V. Classification of fracture:

Mullers sub type	No. of cases	Percentage %
A1	2	10
A3	13	65
B1	2	10
B3	1	5
C2	1	5
C3	1	5



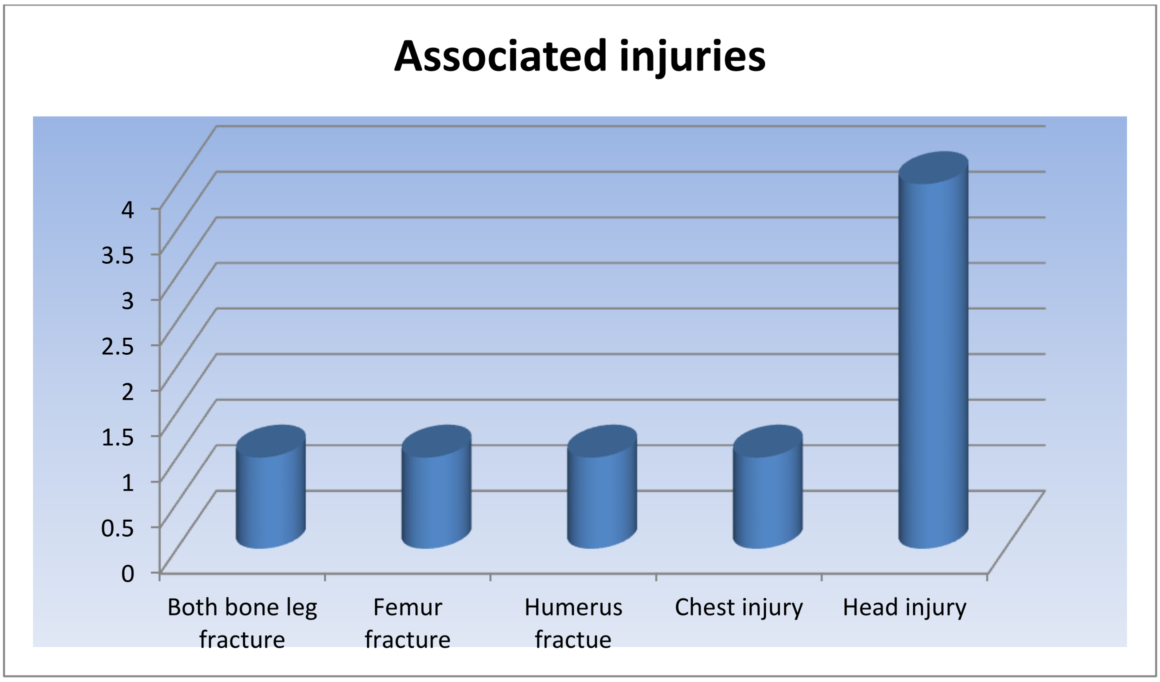
VI. Time interval between injury and surgery

Time interval	No. of cases	Percentage %
<2 days	2	10
2 to 5 days	7	35
5 to 7 days	11	55



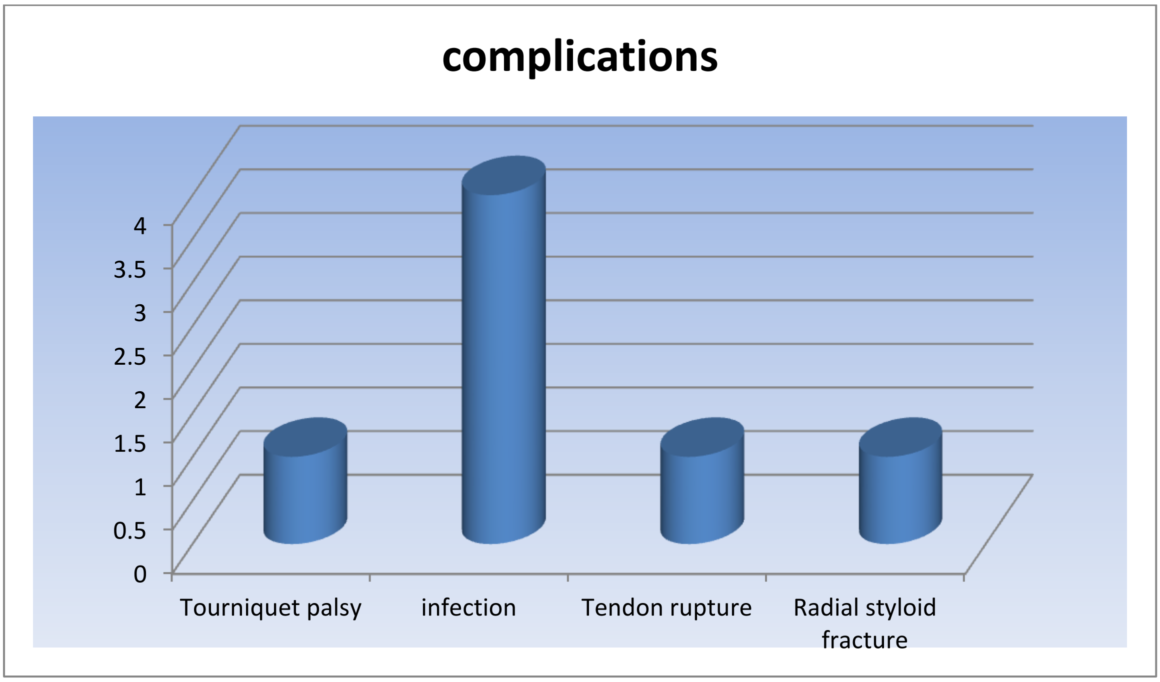
VII. Associated Injuries:

Fracture of both bones leg	1
Humerus shaft fracture	1
Femur fracture	1
Chest injury	1
Head injury	4



VIII. Complications

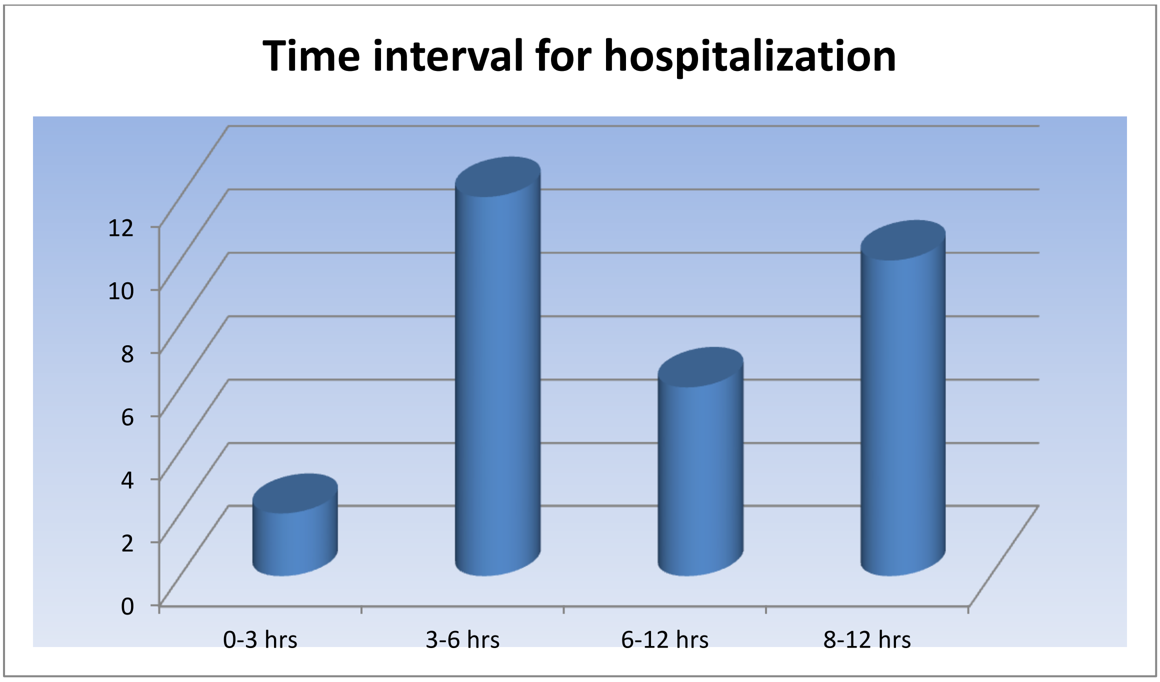
Tourniquet palsy	1 case (recovered)
Infection	4 cases
EPL Tendon injury	1 case
Radial styloid fracture	1 case



IX. Duration between injury and hospitalization

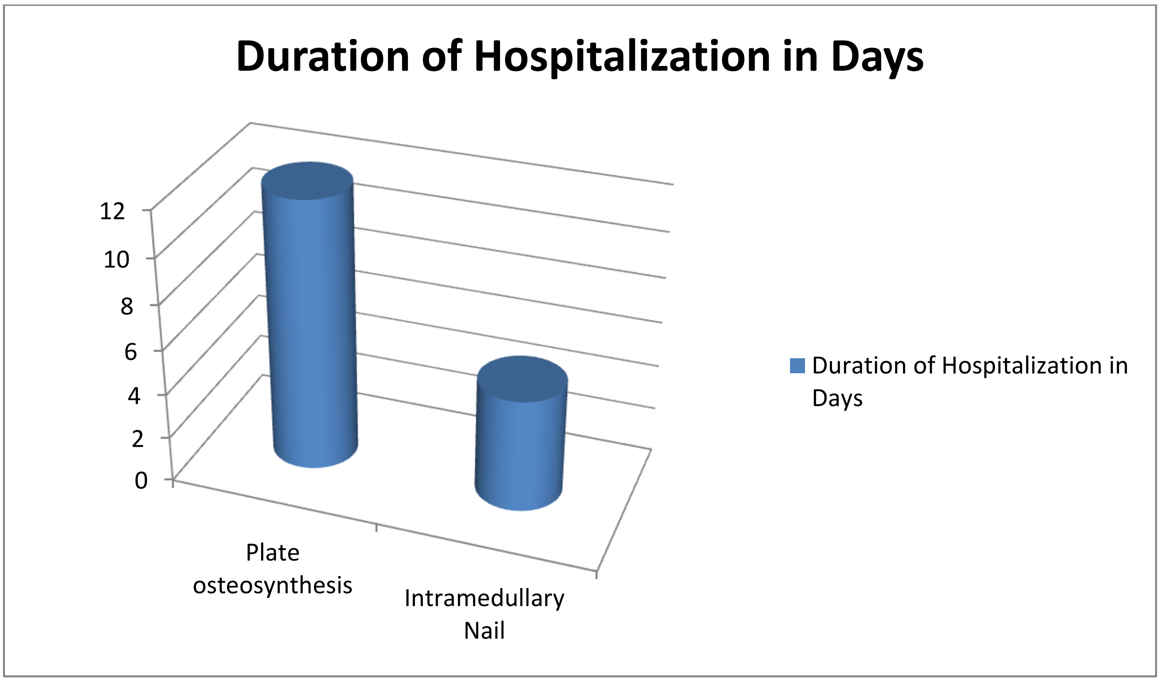
Most of injuries were hospitalized within 12 hours.

Time interval	No. of cases
0 – 3 hrs.	2
3 – 6 hrs.	12
6 – 12 hrs	6
8 -12 hrs	10



X. Duration of hospital stay post operatively

Procedure	Duration of stay
Plate osteosynthesis	12 days
Intramedullary Nail	5 days



PROCEDURE AND POST OPERATIVE PROTOCOL

All the patients were received in the casualty department and were resuscitated. If there were any other major associated injuries, they were treated accordingly at first. After the general condition of the patient improved, radiographs (AP View and lateral view) were taken. The fractures were reduced in closed manner at first under sedation and an above elbow slab was applied.

Most of the cases were taken for elective fixation before 5th day. The patients who had associated major injuries were taken up for surgery between 5th and 7^{h} day.

Open reduction and internal fixation with Dynamic Compression plate:

We routinely used tourniquet during surgery.

The radius was opened first. We always used Henry's approach for exposing the radius. The cleavage between flexor carpi radialis and brachioradialis was developed. The FCR was retracted medially along with radial artery and vein. The branchioradialis was retracted laterally along with the sensory branch of radial nerve. The fractured ends were identified and with minimal periosteal stripping, they were mobilized. The medullary cavity was cleared of any hematoma and the fractured fragments were reduced by carefully matching the interdigitations using bone holding forceps. An Asian DCP of appropriate length was selected and applied to the radius on the volar side and fixed with 3.5mm cortical screws. All the fractures were fixed such that there were at least six cortical purchases on either side of the bony fragment. Then the ulna was opened on its subcutaneous border, centering over the underlying fracture. The interval between flexor carpi ulnaris and extensor carpi ulnaris was identified and developed. The periosteum over the ulna was incised, the fracture fragments were reduced and fixed with an Asian DCP similar to that of radius. Thorough wash of both wounds done. The deep fascia was not sutured; skin closure was done. Compression bandage was applied. Tourniquet was released and an above elbow slab was applied.

POST OPERATIVE PROTOCOL:

In the immediate post operative period the upper limb was immobilized in an above elbow slab, and kept elevated till the edema of fingers subsided. The wound was inspected on the II POD and then suture removal was done on Xth POD. The upper limb was immobilized depending upon the rigidity of fixation. At the end of 4^{th} and 6^{th} weeks check X rays were taken to visualize callus response.. The pronation and supination movements were started by the end of 6th week.

II. Closed Reduction and Fixation with Intra meduallary nailing:

Most of the fractures of Muller type A were fixed with this implant.

(A)Titanium elastic Nail fixation:

The patient is placed supine and the forearm is kept in a hand table compatible with C arm. Tourniquet was not used. The width of the medullary canal of radius was measured and an appropriate sized nail was selected such that, the nail should occupy at least 60% of the medullary space. The entry was made on the distal radius just medial to Lister tubercle, beneath the extensor pollicis longus tendon about 5 mm proximal to wrist joint, with a 3.2 mm drill bit. The medullary canal was entered with a curved awl and the position was confirmed with C arm. The selected titanium elastic nail was introduced and passed into the medullary canal of radius and gently pushed till it reaches the fracture site. The fracture fragments were reduced by gentle manipulation and the nail was entered into the distal fragment by gently rotating the tip. The position of the nail was continuously confirmed with C arm. The nail was passed till it reached the radial neck. The nail was then slightly withdrawn and cut. The cut end of the nail was gently hammered so that the tip lies flush with the bone.

The ulna was entered from the olecranon and an appropriate nail was inserted, fracture fragments reduced and the nail gently manipulated into distal fragment. The tip of the nail was cut and buried. The wounds were sutured.

Post operative protocol:

The upper limb was kept elevated. Wound inspection was done on II POD. Suture removal was done on Xth POD, and above elbow cast was applied. After 3 weeks the cast was removed and a below elbow cast was applied, after obtaining check X rays. Active elbow mobilization exercises were started at the end of 3rd week. By the end of 6 weeks, the cast was discontinued and active pronation and supination exercises were started.

PITFALLS AND THEIR MANAGEMENT

1. Infection:

Four cases developed wound infection, 4 of them treated with plate osteosynthesis – 3 of which are superficial and one deep. Pus culture for sensitivity was sent in all the four cases and treated with appropriate antibiotics. The three superficial infections subsided with treatment for 3 weeks, but the one with deep treatment subsequently went for plate removal for ulna alone. Wound debridement of the ulnar wound was done and the fracture was stabilized with a 3mm K wire.

2. Delayed union:

Delayed union developed in one case treated with titanium elastic nail. The patient had segmental fracture of radius fixed with 3 mm nail. At the end of 6^{th} week, there was tenderness at the proximal segmental fracture site. Radiologically there was no callus. The fracture was immobilized with above elbow cast for another 4 weeks. Eventually there was adequate callus response and the fracture went on to unite well.

3. Elbow stiffness:

3 Patients who were treated with plate osteosynthesis and one patient treated with Titanium elastic nail developed elbow stiffness at the end of 6^{th} week while removing above elbow cast. The patients were put on strict regimen involving active mobilization exercises of elbow. Eventually all 7 patients had good range of motion of elbow.

4. Tendon injury:

One case treated with titanium elastic nail developed rupture of tendon of extensor pollicis longus at the wrist. It occurred during the drilling of outer cortex of distal radius just medial to Lister tubercle. The tendon of EPL was caught by the drill bit while drilling. However there was not gross restriction in range of movements

5. Technical complications:

a) Fracture of Radial styloid:

This complication occurred in a patient treated with titanium elastic nail. The entry point was made more laterally over the radial styloid. During manipulation, the tip of radial styloid fractured. This was visualized on the immediate post operative radiograph. The patient developed wrist stiffness which was treated with intense mobilization exercises.

Case Illustrations : Case No 1

Case No 2








Case No 3






Post op follow up at 6 months

Case No :4

Post op follow up at 6 months

Case no 5

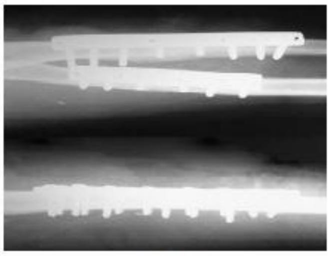
Pre operative X-ray

Immediate post Op X-ray

6 months Post Surgery

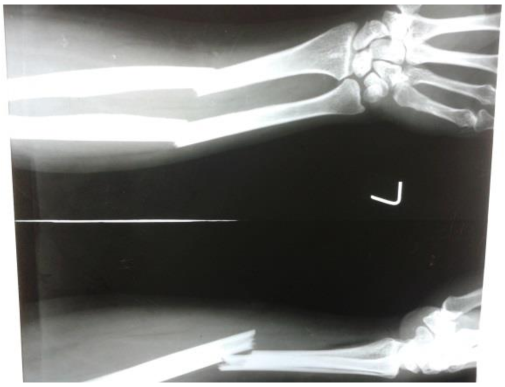
Case no 6

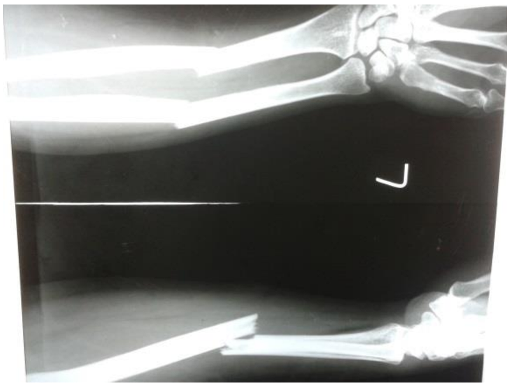
Immediate post Op X-ray



6 months Post Surgery

Case no 7:



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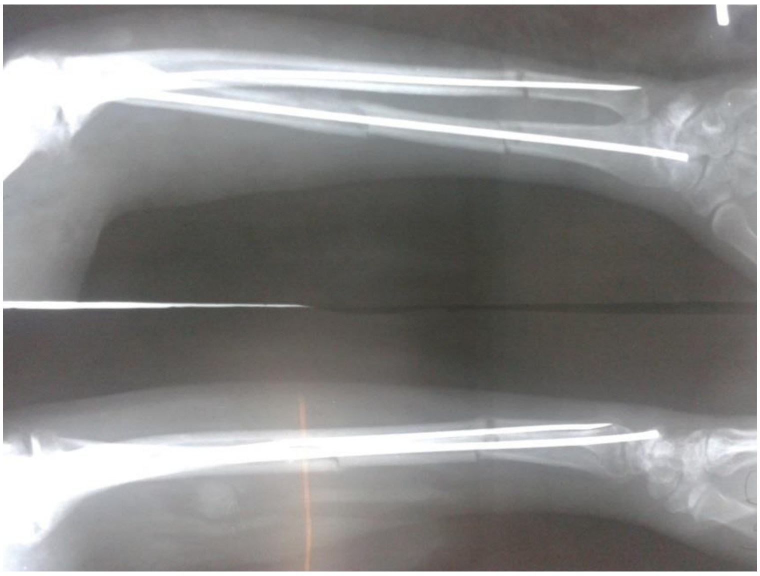
Case no : 8

Pre op and post op x rays followed by x ray at 6 Weeks

Case No: 9

Case No : 10

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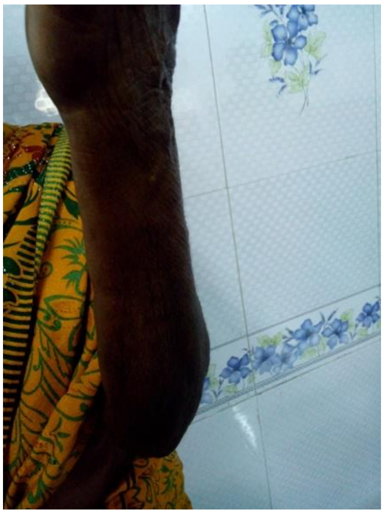
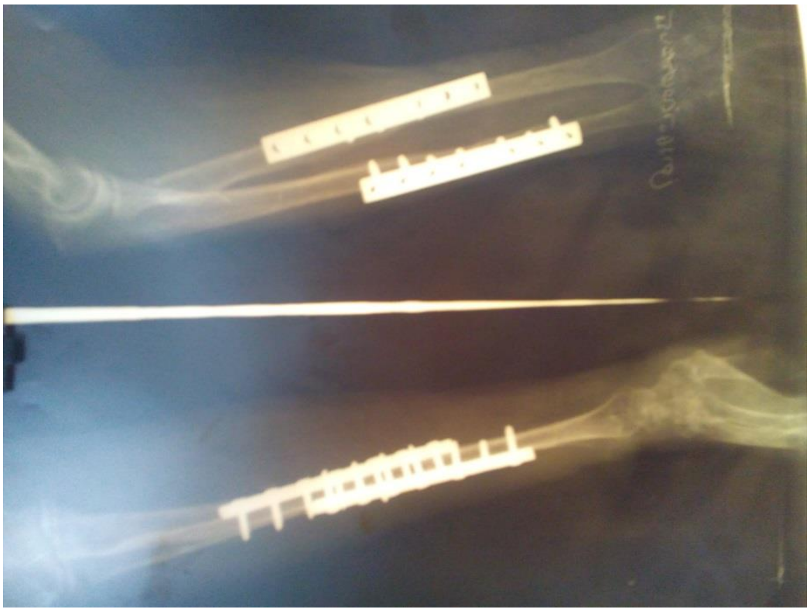
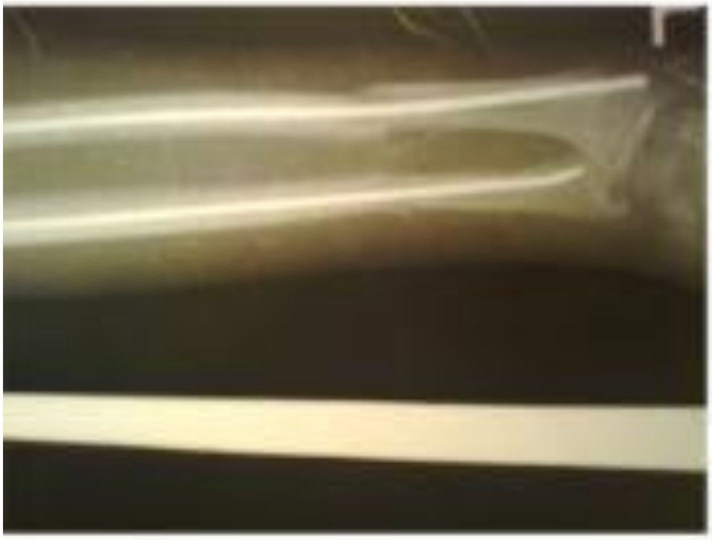




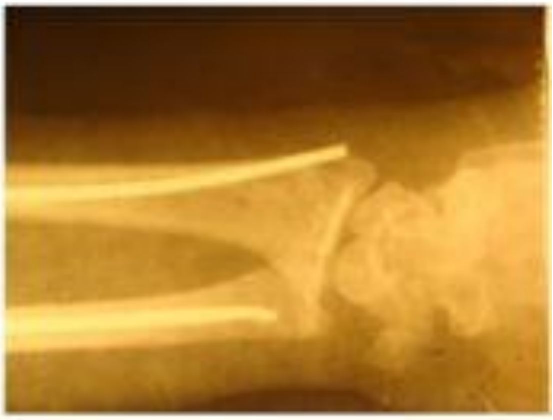



Complications

ANGULATION



RADIAL STYLOID #



CROSS UNION

RESULTS

Average time of fracture healing in our study was 8 weeks. In patients who had undergone plate osteosynthesis, it was 9 weeks whereas in patients who had undergone nail fixation it was 6 weeks. Muller Type 22 A3 fracture united by 11 weeks. Other fracture patterns healed between 6 and 9 weeks. Chapman in a study had 98% union with range of 6 to 14 weeks union the average union time was 12 weeks.[19] Mc Knee study had average union time of 10.7 weeks with range of 5 to 18 weeks. He had 97.3% union rate.

4 patients had restricted pronation & supination. Three patients were treated with plate osteosynthesis and one patient with intramedullary nailng had restricted supination pronation due to cross union. 4 patients treated with plate osteosynthesis gave excellent results with regard to pronation & supination.

4 patients developed post operative stiffness of elbow joint. 3 patients were treated with plate osteosynthesis and one patient with Titanium elastic nail However, all these patients eventually had fair range of motion by the end of 12 weeks following intense physiotherapy.

Chapman et al reported 36 (86%) cases as excellent, 3 (7%) Good,

1 (2%) Fair and 2 (5%) Poor[19] results in his study.

Our series had 90% (18 cases) of excellent /satisfactory results and 10%(2 cases) Poor results which is comparable to the previous studies.

The patient who had sustained fracture of radial styloid process during titanium nail fixation following far lateral entry point developed stiffness of wrist joint. With active exercises, the ROM was increased.

Restoration of pronation & supination activities were possible by the end of 6^{th} week using intramedullary nailing whereas they were possible by the end of 9^{th} week using plate osteosynthesis

However in a study by Sara et al, [20] there was no significant differences between the groups undergoing plate osteosynthesis or Elastic nailing. The risk of non union and reintervention was not different between the groups.

ANALYSIS OF FUNCTIONAL OUTCOME[17]

The Analysis was done using modified GRACE AND EVERSMANN RATING SYSTEM and the following results were obtained.

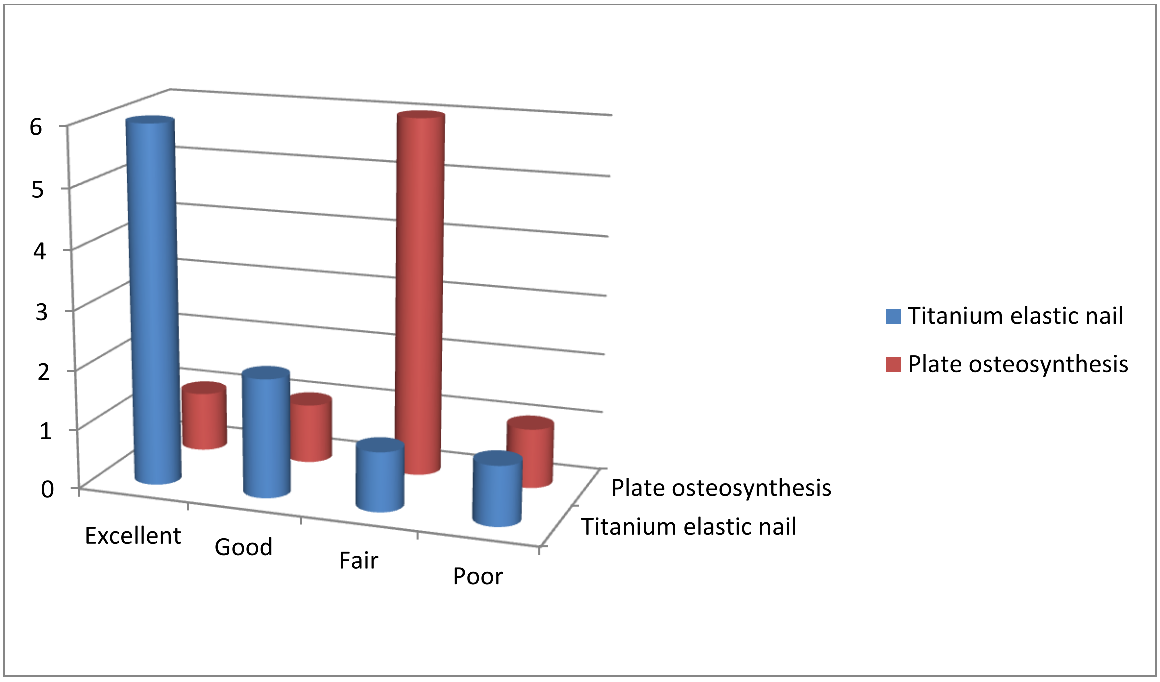
I. OVERALL RESULTS

Grading	Number of Cases	Percentage
Excellent	**7**	**35**
Good	**3**	**15**
Fair	**8**	**40**
Poor	**2**	**10**

II. RESULTS ACCORDING TO IMPLANT USED

Implant	Number of cases	Grading	Percentage
Plate Osteosynthesis	1	Excellent	10
	1	Good	10
	6	Fair	60
	1	Poor	10
	Number of cases	**Grading**	**Percentage**
Titanium Elastic nail	6	Excellent	60
	2	Good	20
	1	Fair	10
	1	Poor	10

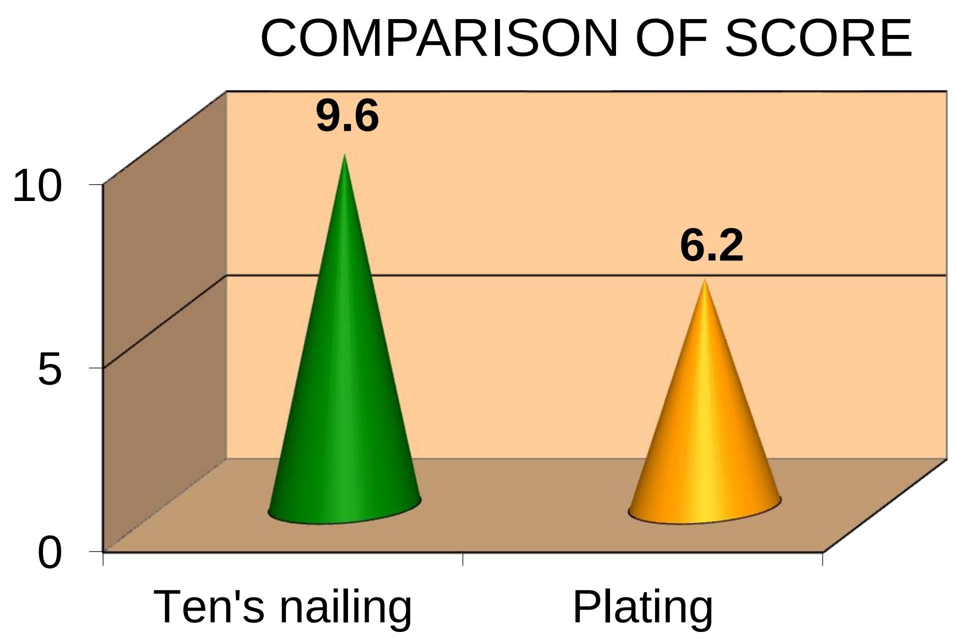
Overall results by Implants used



Statistical Analysis

The mean value of Modified Grace and eversmann score in Patients who underwent nailing is 9.6 and in plating is 6.2 . Standard deviation being 2.17 and 2.15 for patients who underwent nailing and plating respectively.

The P value was found to be 0.002 hence the study supports that Titanium elastic nailing is superior to Plate osteosynthesis.



DISCUSSION

The aim of this study is to compare the results of treating diaphyseal fractures of both bones in adult forearm using plate osteosynthesis with that of titanium elastic nail fixation.

We selected 20 cases of diaphyseal fractures involving both the bones in the forearm in adults. The period of study was between Sep 2012 and Sep 2014. Most of these patients fell into middle age, group with majority of them being males. The mode of violence is either due to RTA, assault or due to accidental fall. The patients who had simple Muller's A3 and segmental fracture pattern were fixed with intramedullary nail fixation and the fractures with comminution were fixed with Intramedullary nailing. Compound fractures were excluded from our study.

A satisfactory device for internal fixation must hold the fracture rigidly, eliminating as completely as possible angular and rotatory motion. This can be accomplished by either a strong intramedullary nail or AO dynamic compression plate.

During plate osteosynthesis, to minimize further injury to blood supply of the bone, the periosteum was stripped sparingly with a periosteal elevator and only sufficiently for applying a plate. The fragments were carefully reduced with interdigitating bone spicules being fitted properly. Comminuted fragments were fitted accurately in place. The plates were selected such that at least there were six cortical purchases on either side of fracture fragments. The plates were contoured before they were applied to the bone. Our study has showed good fracture union occurred in 80% of cases.

Earlier studies have reported an alarming refracture rate of 40% when the plates were removed before 1 year. It is well established that the cortex beneath a rigid plate weakens because of stress shielding, becoming thin, atrophic and almost cancellous in nature. If soft tissue stripping has been extensive, osteonecrosis and revascularization weakens the cortex further. In our series involving 10 cases treated with plate osteosynthesis, we did not have refracture in any of our patients.

While using intramedullary device for fixing the adult forearm fractures involving both bones, rotational control in fractures near the metaphyseo-diaphyseal junction was difficult because of wide medullary canal. Interference fit nails do not maintain bone length if associated with bone loss. When an intramedullary fixation is used, errors in selecting the proper diameter or length of the nail and operative technique contributed to poor results. In case of the titanium elastic nail, the distal end of nail must abut subchondral bone to prevent shortening. The lower modulus of elasticity of titanium nails allow easier insertion and provide more load sharing with the bone. Titanium elastic nails produced interference fit which was responsible for the return of forearm rotation and grip strength.

Our study had showed that good to excellent union occurred with 90% of fractures fixed with titanium elastic nail.

We compared the results of plate fixation with that of intramedullary fixation. Apart from the incidence of infection we did not have any complications while treating forearm fractures with plate osteosynthesis. All the cases healed well on controlling the infection

We had technical difficulties while using both titanium elastic nail. While fixing fractures of radius involving distal 3rd shaft, the titanium elastic nail did not provide with adequate stability of fracture fragments because of wide medullary canal. While using titanium elastic nail we had entry point fracture at radius, since the entry point was shifted far laterally. That led to the fracture of styloid process of radius which was treated conservatively. In another case, there was avulsion of tendon of extensor pollicis longus by a drill bit. This occurred following failure of separation of soft tissue upto the bone with a curved artery forceps after skin incision was made.

Earlier, intramedullary devices like K wires, square nails and Rush nails were used for fixing radius and ulna. These implants did not provide with rotational stability at the fracture site. This lead to higher incidence of non union. But titanium elastic nail, provided with excellent rotational stability of fracture fragments.

We used tourniquet in fractures fixed with plate osteosynthesis. One case of tourniquet palsy occurred but recovered eventually. Since tourniquet was not used during intramedullary fixation, the chance for occurrence of this neurological complication was totally eliminated.

Closed Intramedullary fixation offers the following advantages when compared with plate osteosynthesis.

a) No periosteal stripping is required

b) Smaller operative wound

c) Bone grafting not necessary

d) No potential for diaphyseal refracture after implant exit.

In our study, the rehabilitation time was much shorter for fractures fixed with intramedullary nail when compared with that of plate osteosynthesis. The average time required for functional recovery is more than 9 weeks when plates are used, and about 6 weeks when intramedullary nails are used. The duration of hospital stay post operatively was also less (on an average of 5 days for intramedullary devices and 12 days for plate osteosynthesis).

Intramedullary fixation provides for short operating time, short hospital stay and early rehabilitation .Intramedullary fixation excels better than plate osteosynthesis especially in cases of segmental fractures and Comminuted fractures if closed reduction is possible.

CONCLUSION

The conclusion of this study are

- Diaphyseal fractures of both bones of forearm in adults are one of the commonest fractures being reported to orthopaedic emergency
- Early fixation of fracture followed by intense physiotherapy produced excellent results.
- Fixation with plate osteosynthesis has stood the test of time and provides excellent fixation.
- The advantages of intramedullary fixation are
    - Preservation of fracture hematoma
    - Early mobilization.
    - Can be done as a day care procedure
    - Less post operative morbidity.
    - Smaller incision – hence better cosmesis

o Last, but not the least; since there is no axial loading (like weight bearing) after intramedullary fixation, the chances of implant failure is very less.

- Titanium elastic nail fixation is particularly useful in fractures involving middle third of radius and ulna. Providing for 3 point fixation leads to stable fixation and proper alignment of fracture fragments.
- Being newer techniques, these intramedullary devices require further evaluation and there is a steep learning curve.
- The presence of image control (C arm) helps in easy reduction of fractures fragments thereby shortening intraoperative duration.

To conclude:

Forearm bones fractures are associated with high rates of consolidation and satisfactory mobility of the forearm since we obtain an anatomic reduction of the fracture, as is most easily achieved by plate fixation. However Elastic nailing is a less invasive technique that allows restoring function more quickly with less pain and less risk of complications.

ANEXURE - I

P R O F O R M A

Case No :

NAME : I.P. No :

AGE/SEX

D. O. A :

EDUCATION: D.O.S :

OCCUPATION: D. O. D :

ADDRESS :

CONSULTANT:

1. PRESENTING COMPLAINTS

2. HISTORY OF PRESENT ILLNESS

Mode of injury-Direct / Indirect – RTA

- Assault

- Fall on outstretched hand

- Others

Duration / side affected

3. First Aid Measures immediate

4. Past History

5. Family history

6. Personal History

Occupation: Nature of work

Diet : vegetarian / non vegetarian / mixed

Habits : Smoker / Alcoholic / none

EXAMINATION:

1. General physical examination:

Built:

Vitals - Pulse_____ Beats/min Temp______ °C

B. P;______ mm of Hg R.R--Cycles/min

2. Systemic examination

CVS

RS

PA

CNS

3. Local Examination:

Inspection:

Side

Attitude

Swelling

Deformity

Wounds

Others

Palpation:

Tenderness

Abnormal mobility

Crepitus

Distal pulses Radial artery Ulnar artery

Neurological examination of Peripheral Nerves-Basic

Motor

Sensory

Radial Nerve

Ulnar Nerve

Median Nerve

4. Associated injuries:

5. Complications:

INVESTIGATIONS:

Blood routine- Hemoglobin, Total WBC count

Differential count, ESR

BT, CT, prothrombin time

RBS, B. urea, S.creatinine

HIV 1 and 2, HbsAg

Urine routine

X-ray Forearm – AP,Lateral

Level of fracture

Displacement

Type of fracture

X-ray chest PA View and ECG – if patient is more than 40 years

TREATMENT:

1. Pre-operative treatment:

Above elbow POP slab with sling

Antibiotics, tetanus toxoid

Analgesics

Preoperative evaluation

2. Surgical procedure:

Type of anesthesia - GA/brachial block

Duration of surgery

Approach - Thompson/Henry

Operative findings

Operative Complications

Difficult reduction Stable/Unstable

Placement of Plate and Screws

Insertion of nails

3. Post operative:

Post operative Immobilisation Type and Duration

Antibiotics

Suture removal

Complications

4. **Advice on Discharge**

5. Duration of Hospital stay

6. Follow up

Parameters	**6th week**	**3 months**	**6 months**
Pain			
Radiograph (union)			
Supination & Pronation			
Elbow Flexion,Extension			

7. Complications:

Infection

Delayed union,

Non union, Malunion

Nerve injury

ANNEXURE – II

CONSENT FORM

FOR OPERATION/ANAESTHESIA

I__________ Hosp. No._______ in my full senses hereby give my full

consent for _______ or any other procedure deemed fit which is a diagnostic

procedure / biopsy / transfusion / operation to be performed on me / my son /

my

daughter / my ward______age under any anaesthesia deemed fit. The nature,risks

and

complications involved in the procedure have been explained to me in my own

language and to my satisfaction. For academic and scientific purpose the

operation/procedure may be photographed or televised.

Date:

Signature/Thumb Impression

of Patient/Guardian

Name:

Designation Guardian Relation ship

Full address

Ref.No.6506/E1/5/2014

Madurai Medical College,
Maduai -20 Dated: 19. 08.2014.

Institutional Review Board/Independent Ethics Committee
Capt.Dr.B.Santhakumar,MD (FM). deanmdu@gmail.com
Dean, Madurai Medical College &
Government Rajaji Hospital, Madurai 625 020 . Convenor

Sub: Establishment – Madurai Medical College, Madurai-20 –
Ethics Committee Meeting – Meeting Minutes - for August 2014 –
Approved list – reg.

The Ethics Committee meeting of the Madurai Medical College, Madurai was held on 05th August 2014 at 10.00 Am to 12.00 Noon at Anaesthesia Seminar Hall at Govt. Rajaji Hospital, Madurai . The following members of the Ethics Committee have attended the meeting.

1.Dr.V.Nagarajan,M.D.,D.M(Neuro) Ph: 0452-2629629 Cell No.9843052029 nag9999@gmail.com.	Professor of Neurology (Retired) D.No.72, Vakkil New Street, Simmakkal, Madurai -1	Chairman
2.Dr.Mohan Prasad, MS.M.Ch. Cell.No.9843050822 (Oncology) drbkcmp@gmail.com	Professor & H.O.D of Surgical Oncology (Retired) D.No.32, West Avani Moola Street, Madurai.-1	Member ecretary
3. Dr.L.Santhanalakshmi, MD (Physiology) Cell No.9842593412 dr.l.santhanalakshmi@gmail.com.	Vice Principal, Prof. & H.O.D. Institute of Physiology Madurai Medical College	Member
4.Dr.K.Parameswari, MD(Pharmacology) Cell No.9994026056 drparameswari@yahoo.com.	Director of Pharmacology Madurai Medical College.	Member
5.Dr.S.Vadivel Murugan, MD., (Gen.Medicine) Cell No.9566543048 svadivelmurugan_2007@rediffmail.com.	Professor & H.O.D of Medicine Madurai Medical College	Member
6.Dr.A.Sankaramahalingam, MS., (Gen. Surgery) Cell.No.9443367312 chandrahospitalmdu@gmail.com	Professor & H.O.D. Surgery Madurai Medical College.	Member
7.Mrs.Mercy Immaculate Rubalatha, M.A., Med., Cell.No.9367792650 lathadevadoss86@gmail.com	50/5, Corporation Officer's Quarters, Gandhi Museum Road, Thamukam, Madurai-20.	Member
8.Thiru.Pala.Ramasamy, B.A.,B.L., Cell.No.9842165127 palaramasamy2011@gmail.com	Advocate, D.No.72,Palam Station Road, Sellur, Madurai-20.	Member
9.Thiru.P.K.M.Chelliah, B.A., Cell No.9894349599 pkmandco@gmail.com	Businessman, 21 Jawahar Street, Gandhi Nagar, Madurai-20.	Member

The following Project was approved by the Ethical Committee

Name of P.G.	Course	Name of the Project	Remarks
Dr.S.Nithyananth nithyananthsundar@gmail.com	PG in MS (Orthopaedic) Madurai Medical College, and Govt. Rajaji Hospital, Madurai	**Fractures of both bones forearm – A comparative study on fixation techniques and functional outcome between intramedullary nailing & Plate osteosynthesis.**	**Approved**

Please note that the investigator should adhere the following: She/He should get a detaile informed consent from the patients/participants and maintain it Confidentially.

1. She/He should carry out the work without detrimental to regular activities as well as without extra expenditure to the institution or to Government.
2. She/He should inform the institution Ethical Committee, in case of any change of study procedure, site and investigation or guide.
3. She/He should not deviate the area of the work for which applied for Ethical clearance. She/He should inform the IEC immediately, in case of any adverse events or Serious adverse reactions.
4. She/He should abide to the rules and regulations of the institution.
5. She/He should complete the work within the specific period and if any Extension of time is required He/She should apply for permission again and do the work.
6. She/He should submit the summary of the work to the Ethical Committee on Completion of the work.
7. She/He should not claim any funds from the institution while doing the work or on completion.
8. She/He should understand that the members of IEC have the right to monitor the work with prior intimation.

19.8.14

Member Secretary
Ethical Committee

Chairman
Ethical Committee

DEAN/Convenor
Madurai Medical College & Govt. Rajaji Hospital, Madurai- 20.

To
The above Applicant
-thro. Head of the Department concerned

MASTER CHART

S No.	Age	Sex	Side	Mode of Injury	Type	Time of surgery (day)	Associated injuries	Treat-ment Moda-lities	Weeks			Complications	Score
									Union Time	ROM	Return to work		
1.	60	F	L	RTA	A3	3	-	Plate	9	12	14	Infection	10
2.	25	M	R	Assault	A3	6	-	Plate	9	10	12	-	7
3.	30	M	R	RTA	A1	3	-	Plate	9	12	15	-	8
4.	45	M	R	RTA	A1	6	-	Plate	9	12	15	Infection Stiffness	4
5.	34	M	R	RTA	A3	3	-	Plate	8	12	14	Infection	6
6.	35	F	L	Assault	A3	6	Head injury	Plate	8	12	15	-	5
7.	21	M	R	RTA	B1	5	-	Plate	8	14	15	Stiffness	6
8.	29	F	R	RTA	A3	6	Head injury	Plate	8	12	12	-	5
9.	39	M	R	Assault	A3	4	-	Plate	9	12	13	stiffness	6
10.	45	F	L	Assault	B1	5	Head injury	Plate	9	12	12	infection	5

S No.	Age	Sex	Side	Mode of Injury	Type	Time of surgery (day)	Associated injuries	Treat-ment Moda-lities	Weeks			Complications	Score
									Union Time	ROM	Return to work		
11.	40	M	R	Fall	A3	2	-	TEN	6	9	12	-	12
12.	65	F	R	RTA	A3	7	Fracture both bone leg	TEN	7	9	12	EPL injury	10
13.	47	F	L	RTA	A3	5	Head injury	TEN	6	9	12	-	12
14.	50	M	L	Fall	C2	3	-	TEN	6	10	13	Delayed union	9
15.	29	M	R	RTA	A3	3	Supracondylar fracture femur	TEN	7	9	12	Cross union	7
16.	50	F	L	Assault	A3	5	-	TEN	7	9	14	-	11
17.	35	M	R	RTA	B3	7	Shaft of humerus with intercondylar humerus #	TEN	8	14	20	Elbow stiffness	4
18.	20	F	R	Assault	A3	2	Chest injury	TEN	6	8	12	-	11
19.	52	M	L	Fall	C3	7	-	TEN	6	9	12	-	11
20.	40	M	L	RTA	A3	3	-	TEN	7	10	13	Radial styloid fracture	9

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LIST OF ABBREVATIONS

AO Arbeitsgemeinschaft fur osteosynthesefragen

A-P Antero posterior

ASIF Association for the Study of Internal Fixation

D C P Dynamic compression plate

POP Plaster of paris

AUR Anterior ulnar recurrent

PUR Posterior ulnar recurrent

ORIF Open reduction and internal fixation

R T A Road traffic accident

Fracture

FCR Flexor Carpi radialis

EPL Extensor Pollicis longus

POD Post operative day

TEN Titanium Elastic Nail

M Male

F Female

S no Serial number

L Left

R Right

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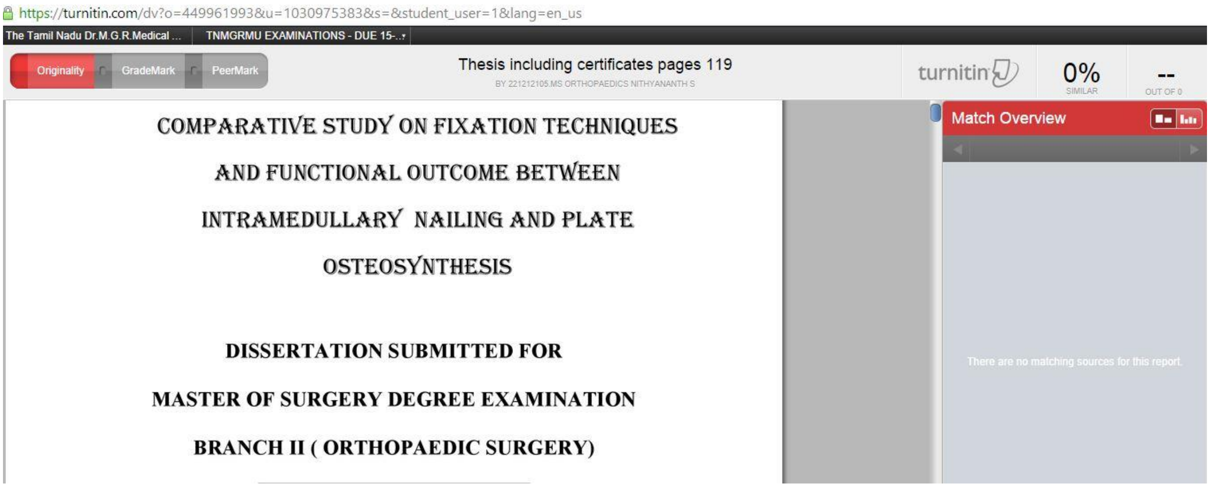
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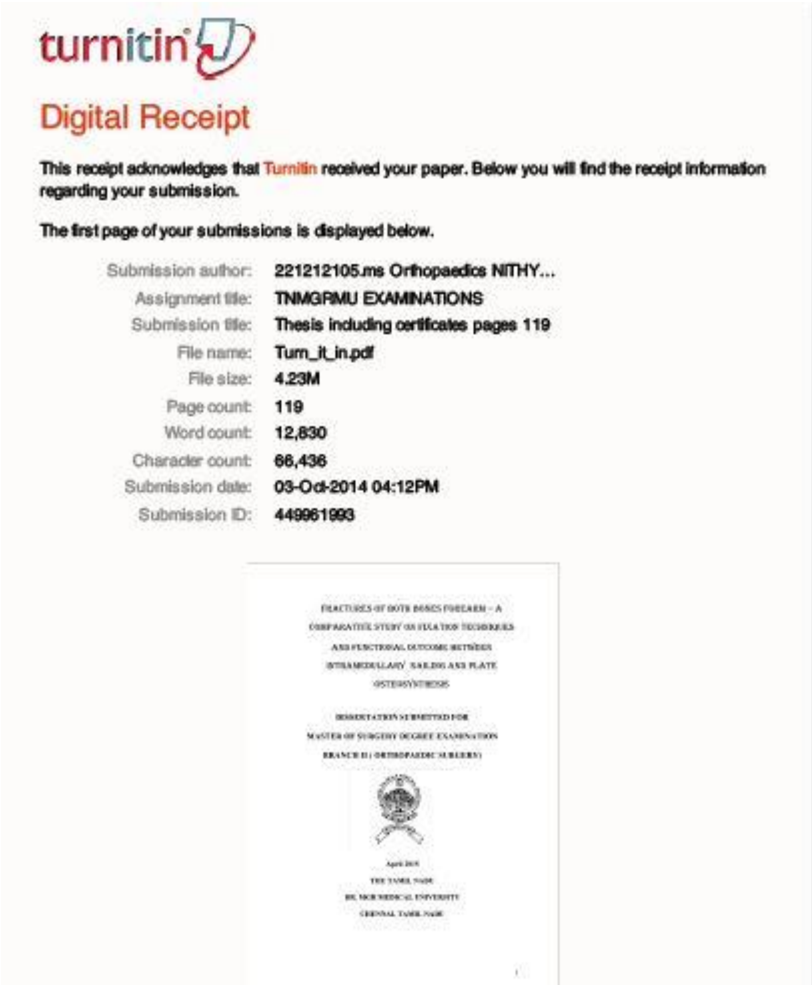
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